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NOVEL DERMATOPHAGOIDES NUCLEIC ACID MOLECULES,
PROTEINS AND USES THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority to prior pending U.S. Patent Application

5 Serial No. 09/292,225, filed April 15, 1999; U.S. Provisional Application Serial
No. 60/098,909, filed September 2, 1998, entitled "NOVEL DERMATOPHAGOIDES
NUCLEIC ACID MOLECULES, PROTEINS AND USES THEREOF"; U.S. Provisional
Application Serial No. 60/085,295, filed May 13, 1998, entitled "NOVEL
DERMATOPHAGOIDES PROTEINS AND USES THEREOF"; and U.S. Application
10 Serial No. 09/062,013, filed April 17, 1998, converted by Petition on May 13, 1998 to
U.S. Provisional Application Serial No. 60/098,565, entitled "NOVEL
DERMATOPHAGOIDES PROTEINS AND USES THEREOF"; each of which is
incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

15 The present invention relates to high molecular weight *Dermatophagoides*
proteins, nucleic acid molecules and therapeutic and diagnostic reagents derived from
such proteins.

BACKGROUND OF THE INVENTION

20 Immunoglobulin E (IgE) mediated allergic symptoms afflict many animals. IgE
antibody production in an animal can induce pathogenic IgE responses including, for
example, atopic disease, asthma and rhinitis. Allergens are proteins or peptides
characterized by their ability to induce a pathogenic IgE response in susceptible
individuals.

House dust mite (e.g., *Dermatophagoides farinae* and *Dermatophagoides pteronyssinus*; *Der f* and *Der p*, respectively) allergens are major causative agents associated with IgE-mediated pathogenesis. Previous investigators have identified two major groups of dust mite allergens in humans, group I (*Der f* I and *Der p* I, Mr 25,000) and group 2 (*Der f* II and *Der p* II, Mr 14,000); reviewed in Chapman, et al., *Allergy*, vol. 52, pp.37-379, 1997. Prior investigators have disclosed nucleotide and/or amino acid sequences for: *Der f* I, *Der f* II, *Der p* I and *Der p* II, U.S. Patent No. 5,552,142, to Thomas et al., issued September 3, 1996, U.S. Patent No. 5,460,977, to Ando et al., issued October 24, 1995, PCT Patent Publication No. WO 95/28424, by Chen et al., published October 26, 1995, U.S. Patent No. 5,433,948, to Thomas et al., issued July 18, 10 1995, PCT Patent Publication No. WO 93/08279, by Garmen et al., published March 4, 1993, or Chapman, *ibid.*; *Der p* III, PCT Patent Publication No. WO 95/15976, by Thomas et al., published June 15, 1995; *Der p* VII, PCT Patent Publication No. WO 94/20614, by Thomas et al., published September 15, 1994; a 40-kilodalton (kd) *Der f* allergen, U.S. Patent No. 5,405,758, to Oka et al., issued April 11, 1995, U.S. Patent No. 15 5,314,991, to Oka et al., issued May 24, 1994; a 70-kd *Der f* allergen which is a heat shock protein (Hsp70), Aki et al., *J. Biochem.*, vol. 115, pp. 435-440, 1994; or Noli et al., *Vet. Immunol. Immunopath.*, vol. 52, pp. 147-157, 1996; and a 98-kd *Der f* paramyosin-like allergen, Tsai et al., *J. Allergy Clin. Immunol.*, vol. 102, pp. 295-303, 1998. None of 20 these published sequences indicates, suggests or predicts any of the mite allergic nucleic acid molecules or proteins of the present invention, nor the relevance of such proteins as being immunoreactive with IgE antibodies in canine, feline, or human sera.

Products and processes of the present invention are needed in the art that provide specific detection and treatment of mite allergy.

SUMMARY OF THE INVENTION

The present invention relates to novel proteins having molecular weights of about

- 5 60 kilodaltons (kd or kD), 70 kD, or from about 98 kD to about 109 kD. Such proteins include at least one epitope of a protein allergen of a mite of the genus *Dermatophagoides* and are designated herein as *Der* HMW-map proteins. Preferred proteins are *Dermatophagoides farinae* or *Dermatophagoides pteronyssinus* proteins. The present invention also provides proteins that are fragments or peptides of full-length or mature proteins, as well as antibodies, mimetopes or muteins of any of such proteins.
- 10 The present invention also provides nucleic acid molecules encoding any of such proteins, as well as complements thereof. The present invention also includes methods to obtain such proteins, nucleic acid molecules, antibodies, mimetopes or muteins, as well as methods to use such compounds in diagnostic or therapeutic applications. The present invention also relates to reagents comprising non-proteinaceous epitopes that bind to IgE in mite-allergic dogs and/or cats as well as to antibodies raised against such epitopes.
- 15 The present invention also relates to therapeutic compositions or assay kits comprising such non-proteinaceous epitopes, as well as to methods to identify and/or desensitize an animal susceptible to an allergic response to a mite, comprising the use of non-proteinaceous epitopes of the present invention.
- 20 One embodiment of the present invention is at least one of the following isolated nucleic acid molecules: (a) a nucleic acid molecule comprising at least about 150 nucleotides, wherein such a nucleic acid molecule hybridizes, in a solution comprising

1X SSC and 0% formamide, at a temperature of about 50°C, to a nucleic acid molecule comprising at least one of the following nucleic acid sequences: SEQ ID NO:14, SEQ ID NO:16, SEQ ID NO:17, SEQ ID NO:19, SEQ ID NO:20, SEQ ID NO:22, SEQ ID NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45, and a nucleic acid sequence encoding a protein comprising the amino acid sequence of SEQ ID NO:33 and a complement thereof; and

5 (b) a nucleic acid molecule comprising a fragment of any of the nucleic acid molecules of (a) wherein the fragment comprises at least about 15 nucleotides. The present invention also includes recombinant molecules, recombinant viruses and recombinant cells comprising such nucleic acid sequences as well as methods to produce them.

10 Another embodiment of the present invention is an isolated protein encoded by at least one of the following nucleic acid molecules: (a) a nucleic acid molecule comprising at least about 150 nucleotides, wherein such a nucleic acid molecule hybridizes, in a solution comprising 1X SSC and 0% formamide, at a temperature of about 50°C, to a nucleic acid molecule comprising at least one of the following nucleic acid sequences: SEQ ID NO:16, SEQ ID NO:19, SEQ ID NO:22, SEQ ID NO:36, SEQ ID NO:39, SEQ ID NO:42, SEQ ID NO:45, and a complement of a nucleic acid sequence encoding a protein comprising the amino acid sequence SEQ ID NO:33; and (b) a nucleic acid molecule comprising a fragment of any of the nucleic acid molecules of (a), wherein the

15 fragment comprises at least about 15 nucleotides. An isolated protein of the present invention can also be encoded by a nucleic acid molecule that hybridizes under stringent hybridization conditions with the complement of a nucleic acid molecule that encodes a protein having at least one of the following amino acid sequences: SEQ ID NO:1, SEQ

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10 ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7,
SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID
NO:13, SEQ ID NO:15, SEQ ID NO:18, SEQ ID NO:21, SEQ ID NO:23, SEQ ID
NO:24, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID
5 NO:33, SEQ ID NO:35, SEQ ID NO:38, SEQ ID NO:41, and SEQ ID NO:44. The
present invention also includes an antibody that selectively binds to a protein of the
present invention as well as methods to produce and use such proteins or antibodies.

15 The present invention also includes a therapeutic composition for treating an
allergic response to a mite. Such a therapeutic composition includes at least one of the
following desensitizing compounds: (a) an isolated nucleic acid molecule of the present
invention; (b) an isolated mite allergenic protein of the present invention; (c) a mimotope
of such a mite allergenic protein; (d) a mutein of such a mite allergenic protein; (e) an
antibody to such a mite allergenic protein; and (f) an inhibitor of binding of such a mite
allergenic protein to IgE. Also included is a method to desensitize a host animal to an
allergic response to a mite. Such a method includes the step of administering to the
animal a therapeutic composition of the present invention.

20 One embodiment of the present invention is an assay kit for testing if an animal is
susceptible to or has an allergic response to a mite. Such a kit includes an isolated
protein of the present invention and a means for determining if the animal is susceptible
to or has that allergic response. Such a means includes use of such a protein to identify
animals susceptible to or having allergic responses to mites. The present invention also
includes a method to identify an animal susceptible to or having an allergic response to a
mite. Such a method includes the steps of: (a) contacting an isolated protein of the

present invention with antibodies of an animal; and (b) determining immunocomplex formation between the protein and the antibodies, wherein formation of the immunocomplex indicates that the animal is susceptible to or has such an allergic response.

5 The present invention includes a reagent that comprises a non-proteinaceous epitope having at least one of the following identifying characteristics: (a) the epitope is resistant to β -elimination of peptides; (b) the epitope is resistant to Proteinase-K digestion; and (c) the epitope is reactive to a test designed to detect glycosylated proteins. Such an epitope binds to at least one of the following antibodies: canine IgE from dogs
10 allergic to mites and feline IgE from cats allergic to mites. Also included is an isolated antibody that selectively binds such a non-proteinaceous epitope as well as derivatives of such an epitope.

15 The present invention also relates to therapeutic compositions and assay kits comprising a non-proteinaceous epitope of the present invention, as well as methods to identify and/or desensitize an animal susceptible to an allergic response to a mite, comprising the use of a non-proteinaceous epitope of the present invention.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1 illustrates high molecular weight *Der f* proteins resolved by 12% Tris-Glycine SDS-PAGE.

20 Fig. 2 illustrates an about 60 kD *Der f* protein resolved by 14% Tris-Glycine SDS-PAGE.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides for isolated proteins having molecular weights ranging from about 60 kilodaltons (kD) to about 109 kD, that include at least one epitope of a protein allergen of a mite of the genus *Dermatophagoides*, in particular a mite of the species *Dermatophagoides farinae* and/or *Dermatophagoides pteronyssius*. Such proteins are referred to herein as *Der* HMW-map proteins. The present invention further includes methods to isolate and identify nucleic acid molecules encoding *Der*HMW-map proteins, antibodies directed against *Der* HMW-map proteins and inhibitors of *Der* HMW-map protein activity. As used herein, the term isolated *Der* HMW-map proteins refers to *Der* HMW-map proteins derived from *Dermatophagoides*, and more preferably from *Dermatophagoides farinae* and/or *Dermatophagoides pteronyssius* and, as such, can be obtained from its natural source or can be produced using, for example, recombinant nucleic acid technology or chemical synthesis. Also included in the present invention is the use of this protein and antibodies in a method to detect immunoglobulin that specifically binds to *Der* HMW-map proteins, to treat pathogenesis against mite allergens, and in other applications, such as those disclosed below. The products and processes of the present invention are advantageous because they enable the detection of anti-*Der* HMW-map antibodies in fluids of animals and the inhibition of IgE or *Der* HMW-map protein activity associated with disease.

One embodiment of the present invention is an isolated *Dermatophagoides* allergenic composition including: (a) a composition produced by a method comprising:

- (1) applying soluble proteins of a *Dermatophagoides* extract to a gel filtration column;
- (2) collecting excluded protein from the gel filtration column and applying the excluded

protein to an anion exchange column; and (3) eluting proteins bound to the anion exchange column with about 0.3 M Tris-HCl, pH 8 to obtain the *Dermatophagoides* allergenic composition; and (b) a composition comprising a peptide of a protein produced in accordance with step (a), in which the allergenic composition is capable of a biological function including binding to IgE, stimulating a B lymphocyte response and stimulating a T lymphocyte response. Such *Dermatophagoides* allergenic composition is also referred to herein as a *Der* HMW-map composition. A suitable gel filtration column includes any gel filtration column capable of excluding proteins having a molecular weight between about 50 kD and about 150 kD. A preferred gel filtration column includes, but is not limited to a Sephadryl S-100 column. A suitable anion exchange column includes any anion exchange column capable of binding to a protein having a pI of less than about pI 6. A preferred anion exchange column includes, but is not limited to a Q-Sepharose column. As used herein, "stimulating a B lymphocyte response" refers to increasing a humoral immune response in an animal that is induced preferentially by a *Der* HMW-map of the present invention and involves the activity of a B lymphocyte in the animal. As used herein, "stimulating a T lymphocyte response" refers to increasing a cellular immune response in an animal that is induced preferentially by a *Der* HMW-map of the present invention and involves the activity of a T lymphocyte in the animal.

One embodiment of the present invention is an isolated protein that includes a *Der* HMW-map protein. It is to be noted that the term "a" or "an" entity refers to one or more of that entity; for example, a protein, a nucleic acid molecule, an antibody, an inhibitor, a compound or a therapeutic composition refers to "one or more" or "at least one" protein, nucleic acid molecule, antibody, inhibitor, compound or therapeutic composition

respectively. As such, the terms "a" (or "an"), "one or more" and "at least one" can be used interchangeably herein. It is also to be noted that the terms "comprising", "including", and "having" can be used interchangeably. According to the present invention, an isolated, or biologically pure, protein, is a protein that has been removed from its natural milieu. As such, "isolated" and "biologically pure" do not necessarily reflect the extent to which the protein has been purified. An isolated protein of the present invention can be obtained from its natural source, can be produced using recombinant DNA technology, or can be produced by chemical synthesis.

As used herein, a *Der* HMW-map protein can be a full-length protein or any homolog of such a protein. As used herein, a protein can be a polypeptide or a peptide, as the terms are used by those of skill in the art. Preferably, a *Der* HMW-map protein comprises at least a portion of a *Der* HMW-map protein that comprises at least one epitope recognized by an IgE antibody (i.e., a protein of the present invention binds to an IgE antibody), an antibody on the surface of a B lymphocyte and/or a T cell receptor in the presence of a major histocompatibility complex (MHC) molecule from an animal demonstrating IgE-mediated pathogenesis to a *Der* HMW-map protein.

A peptide of the present invention includes a *Der* HMW-map protein of the present invention that is capable of binding to IgE, desensitizing an animal against mite allergen, stimulating a B lymphocyte response, and/or stimulating a T lymphocyte response. Preferably, a peptide of the present invention comprises a B lymphocyte epitope or a T lymphocyte epitope. A peptide having a B lymphocyte epitope can bind to an antibody. A peptide having a T lymphocyte epitope can bind to a MHC molecule in such a manner that the peptide can stimulate a T lymphocyte through a T cell receptor.

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According to the present invention, a peptide comprising a B lymphocyte epitope can be from about 4 residues to about 50 residues in length, preferably from about 5 residues to about 20 residues in length. According to the present invention, a peptide comprising a T lymphocyte epitope can be from about 4 residues to about 20 residues in length, preferably from about 8 residues to about 16 residues in length.

A *Der* HMW-map protein of the present invention, including a homolog, can be identified in a straight-forward manner by the protein's ability to induce an allergic response to *Der* HMW-map protein. Examples of *Der* HMW-map protein homologs include *Der* HMW-map protein in which amino acids have been deleted (e.g., a truncated version of the protein, such as a peptide), inserted, inverted, substituted and/or derivatized (e.g., by glycosylation, phosphorylation, acetylation, myristoylation, prenylation, palmitoylation, amidation and/or addition of glycerophosphatidyl inositol) such that the homolog is capable of inducing an allergic response to a natural *Der* HMW-map protein.

Der HMW-map protein homologs can be the result of natural allelic variation or natural mutation. *Der* HMW-map protein homologs of the present invention can also be produced using techniques known in the art including, but not limited to, direct modifications to the protein or modifications to the gene encoding the protein using, for example, classic or recombinant nucleic acid techniques to effect random or targeted mutagenesis.

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One embodiment of the present invention is a *Der* HMW-map gene that includes the nucleic acid sequence SEQ ID NO:14, SEQ ID NO:16, SEQ ID NO:17, SEQ ID NO:19, SEQ ID NO:20 SEQ ID NO:22, SEQ ID NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, and SEQ ID

NO:45 as well as the complements of any of these nucleic acid sequences. These nucleic acid sequences are further described herein. For example, nucleic acid sequence SEQ ID NO:14 represents the deduced sequence of the coding strand of a cDNA (complementary DNA) denoted herein as *Der* HMW-map gene nucleic acid molecule nDerf98₁₇₅₂, the production of which is disclosed in the Examples. Nucleic acid molecule nDerf98₁₇₅₂ comprises an apparently full-length coding region. The complement of SEQ ID NO:14 (represented herein by SEQ ID NO:16) refers to the nucleic acid sequence of the strand complementary to the strand having SEQ ID NO:14, which can easily be determined by those skilled in the art. Likewise, a nucleic acid sequence complement of any nucleic acid sequence of the present invention refers to the nucleic acid sequence of the nucleic acid strand that is complementary to (i.e., can form a double helix with) the strand for which the sequence is cited. It should be noted that since nucleic acid sequencing technology is not entirely error-free, SEQ ID NO:14 (as well as other nucleic acid and protein sequences presented herein) represents an apparent nucleic acid sequence of the nucleic acid molecule encoding a *Der* HMW-map protein of the present invention.

In another embodiment, a *Der* HMW-map gene or nucleic acid molecule can be an allelic variant that includes a similar but not identical sequence to SEQ ID NO:14 or SEQ ID NO:16, or any other *Der* HMW-map nucleic acid sequence cited herein. For example, an allelic variant of a *Der* HMW-map gene including SEQ ID NO:14 or SEQ ID NO:16, is a gene that occurs at essentially the same locus (or loci) in the genome as the gene including SEQ ID NO:14 and SEQ ID NO:16, but which, due to natural variations caused by, for example, mutation or recombination, has a similar but not identical sequence. Because natural selection typically selects against alterations that

affect function, allelic variants (i.e. alleles corresponding to, or of, cited nucleic acid sequences) usually encode proteins having similar activity to that of the protein encoded by the gene to which they are being compared. Allelic variants of genes or nucleic acid molecules can also comprise alterations in the 5' or 3' untranslated regions of the gene (e.g., in regulatory control regions), or can involve alternative splicing of a nascent transcript, thereby bringing alternative exons into juxtaposition. Allelic variants are well known to those skilled in the art and would be expected to occur naturally within a given dust mite such as *Dermatophagoides*, since the respective genomes are diploid, and sexual reproduction will result in the reassortment of alleles.

In one embodiment of the present invention, an isolated *Der* HMW-map protein is encoded by a nucleic acid molecule that hybridizes under stringent hybridization conditions to a gene encoding a *Der* HMW-map protein. The minimal size of a *Der* HMW-map protein of the present invention is a size sufficient to be encoded by a nucleic acid molecule capable of forming a stable hybrid (i.e., hybridizing under stringent hybridization conditions) with the complementary sequence of a nucleic acid molecule encoding the corresponding natural protein. The size of a nucleic acid molecule encoding such a protein is dependent on the nucleic acid composition and the percent homology between the *Der* HMW-map nucleic acid molecule and the complementary nucleic acid sequence. It can easily be understood that the extent of homology required to form a stable hybrid under stringent conditions can vary depending on whether the homologous sequences are interspersed throughout a given nucleic acid molecule or are clustered (i.e., localized) in distinct regions on a given nucleic acid molecule.

The minimal size of a nucleic acid molecule capable of forming a stable hybrid with a gene encoding a *Der* HMW-map protein is typically at least about 12 nucleotides to about 15 nucleotides in length if the nucleic acid molecule is GC-rich and at least about 15 to about 17 bases in length if it is AT-rich. The minimal size of a nucleic acid
5 molecule used to encode a *Der* HMW-map protein homolog of the present invention is from about 12 to about 18 nucleotides in length, preferably about 12 nucleotides, or about 15 nucleotides, or about 18 nucleotides in length. Thus, the minimal size of a *Der* HMW-map protein homolog of the present invention is from about 4 to about 6 amino acids in length. There is no limit, other than a practical limit, on the maximal size of a nucleic
10 acid molecule encoding a *Der* HMW-map protein of the present invention because a nucleic acid molecule of the present invention can include a portion of a gene, an entire gene, or multiple genes. The preferred size of a protein encoded by a nucleic acid molecule of the present invention depends on whether a full-length, fusion, multivalent, or functional portion of such a protein is desired. Preferably, the preferred size of a protein encoded by a nucleic acid molecule of the present invention is a portion of the
15 protein that induces an immune response which is about 30 amino acids, more preferably about 35 amino acids and even more preferably about 44 amino acids in length.

Stringent hybridization conditions are determined based on defined physical properties of the gene to which the nucleic acid molecule is being hybridized, and can be
20 defined mathematically. Stringent hybridization conditions are those experimental parameters that allow an individual skilled in the art to identify significant similarities between heterologous nucleic acid molecules. These conditions are well known to those skilled in the art. See, for example, Sambrook, *et al.*, 1989, *Molecular Cloning: A*

Laboratory Manual, Cold Spring Harbor Labs Press, and Meinkoth, *et al.*, 1984, *Anal.*

Biochem. 138, 267-284, each of which is incorporated by reference herein in its entirety.

As explained in detail in the cited references, the determination of hybridization conditions involves the manipulation of a set of variables including the ionic strength (M ,

5 in moles/liter), the hybridization temperature ($^{\circ}\text{C}$), the concentration of nucleic acid helix destabilizing agents (such as formamide), the average length of the shortest hybrid duplex (n), and the percent G + C composition of the fragment to which an unknown nucleic acid molecule is being hybridized. For nucleic acid molecules of at least about 150

nucleotides, these variables are inserted into a standard mathematical formula to calculate 10 the melting temperature, or T_m , of a given nucleic acid molecule. As defined in the formula below, T_m is the temperature at which two complementary nucleic acid molecule strands will disassociate, assuming 100% complementarity between the two strands:

$$T_m = 81.5^{\circ}\text{C} + 16.6 \log M + 0.41(\%G + C) - 500/n - 0.61(\%\text{formamide}).$$

For nucleic acid molecules smaller than about 50 nucleotides, hybrid stability is defined 15 by the dissociation temperature (T_d), which is defined as the temperature at which 50% of the duplexes dissociate. For these smaller molecules, the stability at a standard ionic strength is defined by the following equation:

$$T_d = 4(G + C) + 2(A + T).$$

A temperature of 5 $^{\circ}\text{C}$ below T_d is used to detect hybridization between perfectly matched 20 molecules.

Also well known to those skilled in the art is how base-pair mismatch, i.e. differences between two nucleic acid molecules being compared, including non-complementarity of bases at a given location, and gaps due to insertion or deletion of one

or more bases at a given location on either of the nucleic acid molecules being compared, will affect T_m or T_d for nucleic acid molecules of different sizes. For example, T_m decreases about 1°C for each 1% of mismatched base-pairs for hybrids greater than about 150 bp, and T_d decreases about 5°C for each mismatched base-pair for hybrids below about 50 bp. Conditions for hybrids between about 50 and about 150 base-pairs can be determined empirically and without undue experimentation using standard laboratory procedures well known to those skilled in the art. These simple procedures allow one skilled in the art to set the hybridization conditions (by altering, for example, the salt concentration, the formamide concentration or the temperature) so that only nucleic acid hybrids with less than a specified % base-pair mismatch will hybridize. Stringent hybridization conditions are commonly understood by those skilled in the art to be those experimental conditions that will allow hybridization between molecules having about 30% or less base-pair mismatch (i.e., about 70% or greater identity). Because one skilled in the art can easily determine whether a given nucleic acid molecule to be tested is less than or greater than about 50 nucleotides, and can therefore choose the appropriate formula for determining hybridization conditions, he or she can determine whether the nucleic acid molecule will hybridize with a given gene under stringent hybridization conditions and similarly whether the nucleic acid molecule will hybridize under conditions designed to allow a desired amount of base pair mismatch.

Hybridization reactions are often carried out by attaching the nucleic acid molecule to be hybridized to a solid support such as a membrane, and then hybridizing with a labeled nucleic acid molecule, typically referred to as a probe, suspended in a hybridization solution. Examples of common hybridization reaction techniques include,

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but are not limited to, the well-known Southern and northern blotting procedures.

Typically, the actual hybridization reaction is done under non-stringent conditions, i.e., at a lower temperature and/or a higher salt concentration, and then high stringency is achieved by washing the membrane in a solution with a higher temperature and/or lower salt concentration in order to achieve the desired stringency.

For example, if the skilled artisan wished to identify a nucleic acid molecule that hybridizes under stringent hybridization conditions with a *Dermatophagoides farinae* and/or *Dermatophagoides pteronyssius* nucleic acid molecule of about 150 bp in length, the following conditions could preferably be used. The average G + C content of

Dermatophagoides farinae and *Dermatophagoides pteronyssius* DNA is about 39%. The unknown nucleic acid molecules would be attached to a support membrane, and the 150 bp probe would be labeled, e.g. with a radioactive tag. The hybridization reaction could be carried out in a solution comprising 2X SSC and 0% formamide, at a temperature of about 37°C (low stringency conditions). Solutions of differing concentrations of SSC can be made by one of skill in the art by diluting a stock solution of 20X SSC (175.3 gram NaCl and about 88.2 gram sodium citrate in 1 liter of water, pH 7) to obtain the desired concentration of SSC. In order to achieve high stringency hybridization, the skilled artisan would calculate the washing conditions required to allow up to 30% base-pair mismatch. For example, in a wash solution comprising 1X SSC and 0% formamide, the T_m of perfect hybrids would be about 80°C:

$$81.5^\circ\text{C} + 16.6 \log (.15\text{M}) + (0.41 \times 39) - (500/150) - (0.61 \times 0) = 80.4^\circ\text{C}.$$

Thus, to achieve hybridization with nucleic acid molecules having about 30% base-pair mismatch, hybridization washes would be carried out at a temperature of about 50°C. It

is thus within the skill of one in the art to calculate additional hybridization temperatures based on the desired percentage base-pair mismatch, formulae and G/C content disclosed herein. For example, it is appreciated by one skilled in the art that as the nucleic acid molecule to be tested for hybridization against nucleic acid molecules of the present invention having sequences specified herein becomes longer than 150 nucleotides, the T_m for a hybridization reaction allowing up to 30% base-pair mismatch will not vary significantly from 50°C.

Furthermore, it is known in the art that there are commercially available computer programs for determining the degree of similarity between two nucleic acid sequences. These computer programs include various known methods to determine the percentage identity and the number and length of gaps between hybrid nucleic acid molecules. Preferred methods to determine the percent identity among amino acid sequences and also among nucleic acid sequences include analysis using one or more of the commercially available computer programs designed to compare and analyze nucleic acid or amino acid sequences. These computer programs include, but are not limited to, GCGTM (available from Genetics Computer Group, Madison, WI), DNAsisTM (available from Hitachi Software, San Bruno, CA) and MacVectorTM (available from the Eastman Kodak Company, New Haven, CT). A preferred method to determine percent identity among amino acid sequences and also among nucleic acid sequences includes using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

One embodiment of the present invention includes *Der* HMW-map proteins. In one embodiment, *Der* HMW-map proteins of the present invention include proteins that,

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when submitted to reducing 12% Tris glycine SDS-PAGE, migrate as bands at a molecular weight of from about 98 kD to about 109 kD, as shown in Fig. 1. The bands in Fig. 1 are obtained when proteins are collected from *Dermataphagoides farinae* mites using the method described in detail in Example 1. Preferably, *Der* HMW-map proteins of the present invention includes proteins having a molecular weight ranging from about 90 kD to about 120 kD, and more preferably from about 98 kD to about 109 kD.

Preferred *Der* HMW-map proteins of the present invention include mapA and mapB, the identification of which is described in the Examples section.

In another embodiment, *Der* HMW-map proteins of the present invention include proteins that, when submitted to reducing 14% Tris glycine SDS-PAGE, migrate as a band at a molecular weight of about 60 kD, as shown in Fig. 2. The band in Fig. 2 is obtained when proteins are collected from *Dermataphagoides farinae* mites using the method described in detail in Example 9. Preferably, *Der* HMW-map proteins of the present invention includes proteins having a molecular weight of about 60 kD. Preferred *Der* HMW-map proteins of the present invention include mapD, the identification of which is described in the Examples section.

In another embodiment, a preferred *Der* HMW-map protein includes a protein encoded by a nucleic acid molecule which is at least about 50 nucleotides, or about 150 nucleotides, and which hybridizes under conditions which preferably allow about 40% or less base pair mismatch, more preferably under conditions which allow about 35% or less base pair mismatch, more preferably under conditions which allow about 30% or less base pair mismatch, more preferably under conditions which allow about 25% or less base pair mismatch, more preferably under conditions which allow about 20% or less

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base pair mismatch, more preferably under conditions which allow about 15% or less
base pair mismatch, more preferably under conditions which allow about 10% or less
base pair mismatch and even more preferably under conditions which allow about 5% or
less base pair mismatch with a nucleic acid molecule selected from the group consisting
5 of SEQ ID NO:16, SEQ ID NO:19, SEQ ID NO:22, SEQ ID NO:36, SEQ ID NO:39,
SEQ ID NO:42, SEQ ID NO:45 and a nucleic acid sequence encoding a protein
comprising the amino acid sequence SEQ ID NO:33 the complement thereof.

Another embodiment of the present invention includes a *Der* HMW-map protein
encoded by a nucleic acid molecule selected from the group consisting of: a nucleic acid
10 molecule comprising at least about 150 nucleotides, wherein said nucleic acid molecule
comprising at least about 150 nucleotides hybridizes, in a solution comprising 1X SSC
and 0% formamide, at a temperature of about 50°C, to a nucleic acid sequence selected
from the group consisting of SEQ ID NO:16, SEQ ID NO:19, SEQ ID NO:22, SEQ ID
NO:36, SEQ ID NO:39, SEQ ID NO:42, SEQ ID NO:45, and a complement of a nucleic
acid sequence encoding a protein comprising the amino acid sequence SEQ ID NO:33;
15 and a nucleic acid molecule comprising a fragment of any of said nucleic acid molecules
comprising at least about 15 nucleotides.

Yet another preferred *Der* HMW-map protein of the present invention includes a
protein encoded by a nucleic acid molecule which is preferably at least about 60%
20 identical, more preferably at least about 65% identical, more preferably at least about
70% identical, more preferably at least about 75% identical, more preferably at least
about 80% identical, more preferably at least about 85% identical, more preferably at
least about 90% identical and even more preferably at least about 95% identical to a

nucleic acid molecule having the nucleic acid sequence SEQ ID NO:14, SEQ ID NO:17, SEQ ID NO:20, SEQ ID NO:34, SEQ ID NO:37, SEQ ID NO:40, SEQ ID NO:43, and/or a complement of a nucleic acid sequence encoding a protein comprising the amino acid sequence SEQ ID NO:33; also preferred are fragments of such proteins. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Additional preferred *Der* HMW-map proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:18, SEQ ID NO:21, SEQ ID NO:23, SEQ ID NO:24, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:35, SEQ ID NO:38, SEQ ID NO:41, SEQ ID NO:44, and proteins comprising homologs of a protein having the amino acid sequence SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:18, SEQ ID NO:21, SEQ ID NO:23, SEQ ID NO:24, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:35, SEQ ID NO:38, SEQ ID NO:41, SEQ ID NO:44 in which such a homolog comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:18, SEQ ID NO:21, SEQ

ID NO:23, SEQ ID NO:24, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:35, SEQ ID NO:38, SEQ ID NO:41, SEQ ID NO:44 Likewise, also preferred are proteins encoded by nucleic acid molecules encoded by nucleic acid molecules having nucleic acid sequence SEQ ID NO:14, SEQ ID NO:17, 5 SEQ ID NO:20, SEQ ID NO:34, SEQ ID NO:37, SEQ ID NO:40, SEQ ID NO:43 and/or a nucleic acid sequence encoding a protein comprising the amino acid sequence SEQ ID NO:33, or by homologs thereof.

A preferred isolated protein of the present invention is a protein encoded by at least one of the following nucleic acid molecules: nDerf98₁₇₅₂, nDerf98₁₆₆₅, nDerf98₁₆₀₈, 10 nDerp98₁₆₂₁, nDerp98₁₅₂₇, nDerp98₁₄₇₀, nDerf60₅₁₀, or allelic variants of any of these nucleic acid molecules. Another preferred isolated protein is encoded by a nucleic acid molecule having nucleic acid sequence SEQ ID NO:14, SEQ ID NO:17, SEQ ID NO:20, SEQ ID NO:34, SEQ ID NO:37, SEQ ID NO:40, SEQ ID NO:43; or a protein encoded by an allelic variant of any of these listed nucleic acid molecule.

15 Translation of SEQ ID NO:14, the coding strand of nDerf98₁₇₅₂, yields a protein of about 555 amino acids, denoted herein as PDerf98₅₅₅, the amino acid sequence of which is presented in SEQ ID NO:15, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:14. The complementary strand of SEQ ID NO:14 is presented herein as SEQ ID NO:16. The amino acid sequence of PDerf98₅₅₅ is 20 encoded by the nucleic acid molecule nDerf98₁₆₆₅, having a coding strand denoted SEQ ID NO:17 and a complementary strand denoted SEQ ID NO:19. Analysis of SEQ ID NO:15 suggests the presence of a signal peptide spanning from about amino acid 1 through about amino acid 19. The proposed mature protein, denoted herein as

PDerf98₅₃₆, contains about 536 amino acids, the sequence of which is represented herein as SEQ ID NO:21, and is encoded by a nucleic acid molecule referred to herein as nDerf98₁₆₀₈, represented by SEQ ID NO:20, the coding strand, and SEQ ID NO:22, the complementary strand.

5 Translation of SEQ ID NO:34, the coding strand of nDerf98₁₆₂₁, yields a protein of about 509 amino acids, denoted herein as PDerf98₅₀₉, the amino acid sequence of which is presented in SEQ ID NO:35, assuming a first in-frame codon extending from nucleotide 14 to nucleotide 16 of SEQ ID NO:34. The complementary strand of SEQ ID NO:34 is presented herein as SEQ ID NO:36. The amino acid sequence of PDerf98₅₀₉ is
10. encoded by the nucleic acid molecule nDerf98₁₅₂₇, having a coding strand denoted SEQ ID NO:37 and a complementary strand denoted SEQ ID NO:39. Analysis of SEQ ID NO:35 suggests the presence of a signal peptide spanning from about amino acid 1 through about amino acid 19. The proposed mature protein, denoted herein as PDerf98₄₉₀, contains about 490 amino acids, the sequence of which is represented herein as
15 SEQ ID NO:41, and is encoded by a nucleic acid molecule referred to herein as nDerf98₁₄₇₀, represented by SEQ ID NO:40, the coding strand, and SEQ ID NO:42, the complementary strand.

Translation of SEQ ID NO:43, the coding strand of nDerf60₅₁₀, a nucleic acid molecule encoding a portion of the *D. farinae* 60-kD antigen protein yields a protein of
20 about 170 amino acids, denoted herein as PDerf60₁₇₀, the amino acid sequence of which is presented as SEQ ID NO:44, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:43. The complementary sequence to SEQ ID NO:43 is presented herein as SEQ ID NO:45.

Preferred *Der* HMW-map proteins of the present invention include proteins that are at least about 45%, preferably at least about 50%, more preferably at least about 55%, even more preferably at least about 60%, even more preferably at least about 65%, even more preferably at least about 70%, even more preferably at least about 75%, even more preferably at least about 80%, even more preferably at least about 85%, even more preferably at least about 90%, and even more preferably about 95% identical to PDerf98₅₅₅. More preferred is a *Der* HMW-map protein comprising PDerf98₅₅₅, PDerf98₅₃₆, PDerp98₅₀₉, PDerp98₄₉₀, and/or PDerf60₁₇₀; and proteins encoded by allelic variants of nucleic acid molecules encoding proteins PDerf98₅₅₅, PDerf98₅₃₆, PDerp98₅₀₉, PDerp98₄₉₀, and/or PDerf60₁₇₀.

Other preferred *Der* HMW-map proteins of the present invention include proteins having amino acid sequences that are at least about 45%, preferably at least about 50%, more preferably at least about 55%, even more preferably at least about 60%, even more preferably at least about 65%, even more preferably at least about 70%, even more preferably at least about 75%, even more preferably at least about 80%, even more preferably at least about 85%, even more preferably at least about 90%, and even more preferably about 95% identical to amino acid sequence SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:18, SEQ ID NO:21, SEQ ID NO:23, SEQ ID NO:24, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:35, SEQ ID NO:38, SEQ ID NO:41, and/or SEQ ID NO:44. More preferred are *Der* HMW-map proteins comprising amino acid sequences SEQ ID NO:1, SEQ ID NO:2,

SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:18, SEQ ID NO:21, SEQ ID NO:23, SEQ ID NO:24, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:35, SEQ ID NO:38, SEQ ID NO:41, and/or SEQ ID NO:44; and *Der* HMW-map proteins encoded by allelic variants of nucleic acid molecules encoding *Der* HMW-map proteins having amino acid sequences SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:18, SEQ ID NO:21, SEQ ID NO:23, SEQ ID NO:24, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:35, SEQ ID NO:38, SEQ ID NO:41, and/or SEQ ID NO:44.

In one embodiment of the present invention, *Der* HMW-map proteins comprise amino acid sequence SEQ ID NO:15, SEQ ID NO:35, and/or SEQ ID NO:44 (including, but not limited to, the proteins consisting of amino acid sequence SEQ ID NO:15, SEQ ID NO:35, and/or SEQ ID NO:44, fragments thereof, fusion proteins and multivalent proteins), and proteins encoded by allelic variants of nucleic acid molecules encoding proteins having amino acid sequence SEQ ID NO:15, SEQ ID NO:35, and/or SEQ ID NO:44.

In one embodiment, a preferred *Der* HMW-map protein comprises an amino acid sequence of at least about 35 amino acids in length, preferably at least about 50 amino acids in length, more preferably at least about 100 amino acids in length, more preferably at least about 200 amino acids in length, even more preferably at least about 250 amino

acids in length. Within this embodiment, a preferred *Der* HMW-map protein of the present invention has an amino acid sequence comprising at least a portion of SEQ ID NO:15. In another embodiment, a preferred *Der* HMW-map protein comprises a full-length protein, i.e., a protein encoded by a full-length coding region.

5 Additional preferred *Der* HMW-map proteins of the present invention include proteins encoded by nucleic acid molecules comprising at least a portion of nDerf98₁₇₅₂, nDerf98₁₆₆₅, nDerf98₁₆₀₈, nDerp98₁₆₂₁, nDerp98₁₅₂₇, nDerp98₁₄₇₀, and nDerf60₅₁₀, as well as *Der* HMW-map proteins encoded by allelic variants of such nucleic acid molecules.

10 Also preferred are *Der* HMW-map proteins encoded by nucleic acid molecules having nucleic acid sequences comprising at least a portion of SEQ ID NO:14, SEQ ID NO:17, SEQ ID NO:20, SEQ ID NO:34, SEQ ID NO:37, SEQ ID NO:40 SEQ ID NO:43 and/or a nucleic acid sequence encoding a protein comprising the amino acid sequence SEQ ID NO:33, as well as allelic variants of these nucleic acid molecules.

15 In another embodiment, a preferred *Der* HMW-map protein of the present invention is encoded by a nucleic acid molecule comprising at least about 12 nucleotides, preferably at least about 16 nucleotides, more preferably at least about 18 nucleotides, more preferably at least about 20 nucleotides, more preferably at least about 25 nucleotides, more preferably at least about 50 nucleotides, more preferably at least about 100 nucleotides, more preferably at least about 350 nucleotides, more preferably at least about 20 about 450 nucleotides, more preferably at least about 500 nucleotides, and even more preferably at least about 800 nucleotides. Within this embodiment is a *Der* HMW-map protein encoded by at least a portion nDerf98₁₇₅₂, nDerp98₁₆₂₁, and/or nDerf60₅₁₀ or by an allelic variant of these nucleic acid molecules. In yet another embodiment, a preferred

Der HMW-map protein of the present invention is encoded by a nucleic acid molecule comprising an apparently full-length *Der* HMW-map coding region, i.e., a nucleic acid molecule encoding an apparently full-length *Der* HMW-map protein.

One embodiment of a *Der* HMW-map protein of the present invention is a fusion protein that includes a *Der* HMW-map protein-containing domain attached to one or more fusion segments. Suitable fusion segments for use with the present invention include, but are not limited to, segments that can: enhance a protein's stability; act as an immunopotentiator to enhance an immune response against a *Der* HMW-map protein, reduce an IgE response against a *Der* HMW-map protein; and/or assist purification of a *Der* HMW-map protein (e.g., by affinity chromatography). A suitable fusion segment can be a domain of any size that has the desired function (e.g., imparts increased stability, imparts increased immunogenicity to a protein, reduces an IgE response, and/or simplifies purification of a protein). Fusion segments can be joined to amino and/or carboxyl termini of the *Der* HMW-map protein-containing domain of the protein and can be susceptible to cleavage in order to enable straight-forward recovery of a *Der* HMW-map protein. Fusion proteins are preferably produced by culturing a recombinant cell transformed with a fusion nucleic acid molecule that encodes a protein including the fusion segment attached to either the carboxyl and/or amino terminal end of a *Der* HMW-map protein-containing domain. Preferred fusion segments include a metal binding domain (e.g., a poly-histidine segment); an immunoglobulin binding domain (e.g., Protein A; Protein G; T cell; B cell; Fc receptor or complement protein antibody-binding domains); a sugar binding domain (e.g., a maltose binding domain); a "tag" domain (e.g., at least a portion of β -galactosidase, a strep tag peptide, other domains that can be purified

using compounds that bind to the domain, such as monoclonal antibodies); and/or a linker and enzyme domain (e.g., alkaline phosphatase domain connected to a *Der* HMW-map protein by a linker). More preferred fusion segments include metal binding domains, such as a poly-histidine segment; a maltose binding domain; a strep tag peptide, such as 5 that available from Biometra in Tampa, FL; and a phage T7 S10 peptide.

In another embodiment, a *Der* HMW-map protein of the present invention also includes at least one additional protein segment that is capable of desensitizing an animal from one or more allergens. Such a multivalent desensitizing protein can be produced by culturing a cell transformed with a nucleic acid molecule comprising two or more nucleic 10 acid domains joined together in such a manner that the resulting nucleic acid molecule is expressed as a multivalent desensitizing compound containing at least two desensitizing compounds capable of desensitizing an animal from allergens.

Examples of multivalent desensitizing compounds include, but are not limited to, a *Der* HMW-map protein of the present invention attached to one or more compounds 15 that desensitize against allergies caused by one or more allergens, such as a plant allergen, an animal allergen, a parasite allergen or an ectoparasite allergen, including, but not limited to: pant allergens from grass, Meadow Fescue, Curly Dock, plantain, Mexican Firebush, Lamb's Quarters, pigweed, ragweed, sage, elm, cocklebur, Box Elder, walnut, cottonwood, ash, birch, cedar, oak, mulberry, cockroach, *Dermatophagoides*, *Alternaria*, 20 *Aspergillus*, *Cladosporium*, *Fusarium*, *Helminthosporium*, *Mucor*, *Penicillium*, *Pullularia*, *Rhizopus* and/or *Trichophyton*; parasite allergens from helminths; or ectoparasite allergens from arachnids, insects and leeches, including fleas, ticks, flies,

mosquitos, sand flies, black flies, horse flies, horn flies, deer flies, tsetse flies, stable flies, myiasis-causing flies and biting gnats, ants, spiders, lice; mites and true bugs.

The present invention also includes mimetopes of a *Der* HMW-map protein of the present invention. As used herein, a mimotope of a *Der* HMW-map protein of the present invention refers to any compound that is able to mimic the activity of such a *Der* HMW-map protein (e.g., ability to bind to induce an immune response against *Der* HMW-map protein), often because the mimotope has a structure that mimics the *Der* HMW-map protein. It is to be noted, however, that the mimotope need not have a structure similar to a *Der* HMW-map protein as long as the mimotope functionally mimics the protein.

Mimetopes can be, but are not limited to: peptides that have been modified to decrease their susceptibility to degradation; anti-idiotypic and/or catalytic antibodies, or fragments thereof; non-proteinaceous immunogenic portions of an isolated protein (e.g., carbohydrate structures); synthetic or natural organic or inorganic molecules, including nucleic acids; and/or any other peptidomimetic compounds. Mimetopes of the present invention can be designed using computer-generated structures of *Der* HMW-map protein of the present invention. Mimetopes can also be obtained by generating random samples of molecules, such as oligonucleotides, peptides or other organic molecules, and screening such samples by affinity chromatography techniques using the corresponding binding partner, (e.g., an anti-*Der* HMW-map protein antibody). A mimotope can also be obtained by, for example, rational drug design. In a rational drug design procedure, the three-dimensional structure of a compound of the present invention can be analyzed by, for example, nuclear magnetic resonance (NMR) or x-ray crystallography. The three-dimensional structure can then be used to predict structures of potential mimetopes by,

for example, computer modeling. The predicted mimotope structures can then be produced by, for example, chemical synthesis, recombinant DNA technology, or by isolating a mimotope from a natural source. Specific examples of *Der* HMW-map protein mimotopes include anti-idiotypic antibodies, oligonucleotides produced using Selex™ technology, peptides identified by random screening of peptide libraries and proteins identified by phage display technology. A preferred mimotope is a peptidomimetic compound that is structurally and/or functionally similar to a *Der* HMW-map protein of the present invention, particularly to an epitope of *Der* HMW-map protein that induces an immune response.

10 The present invention also includes muteins of a *Der* HMW-map protein of the present invention. As used herein, a mutein refers to a particular homolog of a *Der* HMW-map protein in which desired amino acid residues have been substituted or removed. Preferred muteins of the present invention include *Der* HMW-map protein homologs in which amino acid residues have been changed to reduce an anaphylactic reaction by an animal when the mutein is administered to the animal in therapeutic doses. 15 More preferred muteins of the present invention include *Der* HMW-map protein homologs in which one or more cysteine residues of a *Der* HMW-map protein have been replaced or removed. Methods to produce muteins are known to those of skill in the art and are disclosed herein. Preferably, a mutein is produced using recombinant techniques.

20 Another embodiment of the present invention is an isolated nucleic acid molecule comprising a *Der* HMW-map nucleic acid molecule. The identifying characteristics of such nucleic acid molecules are heretofore described. A nucleic acid molecule of the present invention can include an isolated natural *Der* HMW-map gene or a homolog

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thereof, the latter of which is described in more detail below. A nucleic acid molecule of the present invention can include one or more regulatory regions, full-length or partial coding regions, or combinations thereof. The minimal size of a nucleic acid molecule of the present invention is a size sufficient to allow the formation of a stable hybrid (i.e., hybridization under stringent hybridization conditions) with the complementary sequence of another nucleic acid molecule.

In accordance with the present invention, an isolated nucleic acid molecule is a nucleic acid molecule that has been removed from its natural milieu (i.e., that has been subjected to human manipulation) and can include DNA, RNA, or derivatives of either DNA or RNA. As such, "isolated" does not reflect the extent to which the nucleic acid molecule has been purified. An isolated *Der* HMW-map nucleic acid molecule of the present invention, or a homolog thereof, can be isolated from its natural source or produced using recombinant DNA technology (e.g., polymerase chain reaction (PCR) amplification or cloning) or chemical synthesis. Isolated *Der* HMW-map nucleic acid molecules, and homologs thereof, can include, for example, natural allelic variants and nucleic acid molecules modified by nucleotide insertions, deletions, substitutions, and/or inversions in a manner such that the modifications do not substantially interfere with the nucleic acid molecule's ability to encode a *Der* HMW-map protein of the present invention.

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A *Der* HMW-map nucleic acid molecule homolog can be produced using a number of methods known to those skilled in the art, see, for example, Sambrook et al., 1989, *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor Labs Press; Sambrook et al., *ibid.*, is incorporated by reference herein in its entirety. For example,

nucleic acid molecules can be modified using a variety of techniques including, but not limited to, classic mutagenesis and recombinant DNA techniques such as site-directed mutagenesis, chemical treatment, restriction enzyme cleavage, ligation of nucleic acid fragments, PCR amplification, synthesis of oligonucleotide mixtures and ligation of mixture groups to "build" a mixture of nucleic acid molecules, and combinations thereof.

5 Nucleic acid molecule homologs can be selected by hybridization with a *Der* HMW-map nucleic acid molecule or by screening the function of a protein encoded by the nucleic acid molecule (e.g., ability to elicit an immune response against at least one epitope of a *Der* HMW-map protein or to effect *Der* HMW-map activity).

10 Allelic variants typically encode proteins having similar activity to that of the protein encoded by the gene to which they are being compared. Allelic variants can also comprise alterations in the 5' or 3' untranslated regions of the gene (e.g., in regulatory control regions). Allelic variants are well known to those skilled in the art and would be expected to be found within a given dust mite since the genome is diploid and/or among a group of two or more dust mites. The present invention also includes variants due to 15 laboratory manipulation, such as, but not limited to, variants produced during polymerase chain reaction amplification.

An isolated nucleic acid molecule of the present invention can include a nucleic acid sequence that encodes at least one *Der* HMW-map protein of the present invention, examples of such proteins being disclosed herein. Although the phrase "nucleic acid 20 molecule" primarily refers to the physical nucleic acid molecule and the phrase "nucleic acid sequence" primarily refers to the sequence of nucleotides on the nucleic acid molecule, the two phrases can be used interchangeably, especially with respect to a

nucleic acid molecule, or a nucleic acid sequence, being capable of encoding a *Der* HMW-map protein.

A preferred nucleic acid molecule of the present invention, when administered to an animal, is capable of desensitizing that animal from allergic reactions caused by a *Der* HMW-map allergen. As will be disclosed in more detail below, such a nucleic acid molecule can be, or encode, an antisense RNA, a molecule capable of triple helix formation, a ribozyme, or other nucleic acid-based drug compound. In additional embodiments, a nucleic acid molecule of the present invention can encode a desensitizing protein (e.g., a *Der* HMW-map protein of the present invention), the nucleic acid molecule being delivered to the animal, for example, by direct injection (i.e., as a DNA reagent) or in a vehicle such as a recombinant virus reagent or a recombinant cell reagent.

One embodiment of the present invention is an isolated nucleic acid molecule that hybridizes under stringent hybridization conditions with a *Der* HMW-map gene.

Stringent hybridization conditions refer to standard hybridization conditions described herein. A preferred nucleic acid molecule of the present invention includes an isolated nucleic acid molecule that hybridizes under stringent hybridization conditions with a gene encoding a protein comprising an amino acid sequence including SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:18, SEQ ID NO:21, SEQ ID NO:23, SEQ ID NO:24, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:35, SEQ ID NO:38, SEQ ID NO:41, and/or SEQ ID NO:44. A more preferred nucleic acid molecule of the present invention includes an isolated nucleic acid

molecule that hybridizes under stringent hybridization conditions with the complement of
a nucleic acid sequence that encodes a protein comprising an amino acid sequence
including SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5,
SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID
5 NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:18, SEQ ID
NO:21, SEQ ID NO:23, SEQ ID NO:24, SEQ ID NO:29, SEQ ID NO:30, SEQ ID
NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:35, SEQ ID NO:38, SEQ ID
NO:41, and/or SEQ ID NO:44.

A more preferred nucleic acid molecule of the present invention includes an
10 isolated nucleic acid molecule selected from the group consisting of: a nucleic acid
molecule comprising at least about 150 nucleotides, wherein said nucleic acid molecule
comprising at least about 150 nucleotides hybridizes, in a solution comprising 1X SSC
and 0% formamide, at a temperature of about 50°C, to a nucleic acid sequence selected
from the group consisting of SEQ ID NO:14, SEQ ID NO:16, SEQ ID NO:17, SEQ ID
15 NO:19, SEQ ID NO:20, SEQ ID NO:22, SEQ ID NO:34, SEQ ID NO:36, SEQ ID
NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID
NO:45 and/or a nucleic acid sequence encoding a protein comprising the amino acid
sequence SEQ ID NO:33 and a complement thereof.

The present invention also includes fragments of any nucleic acid molecule
20 disclosed herein. According to the present invention, a fragment can include any nucleic
acid molecule or nucleic acid sequence, the size of which can range between a length that
is smaller than a sequence identified by a SEQ ID NO of the present invention and the
minimum size of an oligonucleotide as defined herein. For example, the size of a

fragment of the present invention can be any size that is less than about 1752 nucleotides and greater than 11 nucleotides in length.

In one embodiment of the present invention, a preferred *Der* HMW-map nucleic acid molecule includes an isolated nucleic acid molecule which is at least about 50 nucleotides, or at least about 150 nucleotides, and which hybridizes under conditions which preferably allow about 40% or less base pair mismatch, more preferably under conditions which allow about 35% or less base pair mismatch, more preferably under conditions which allow about 30% or less base pair mismatch, more preferably under conditions which allow about 25% or less base pair mismatch, more preferably under conditions which allow about 20% or less base pair mismatch, more preferably under conditions which allow about 15% or less base pair mismatch, more preferably under conditions which allow about 10% or less base pair mismatch and even more preferably under conditions which allow about 5% or less base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:14, SEQ ID NO:16, SEQ ID NO:17, SEQ ID NO:19, SEQ ID NO:20, SEQ ID NO:22, SEQ ID NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45, and a nucleic acid sequence encoding a protein comprising the amino acid sequence SEQ ID NO:33 and a complement thereof.

Another embodiment of the present invention includes a nucleic acid molecule comprising at least about 150 base-pairs, wherein the nucleic acid molecule hybridizes, in a solution comprising 1X SSC and 0% formamide, at a temperature of about 50°C, to a nucleic acid sequence selected from the group consisting of SEQ ID NO:14, SEQ ID NO:16, SEQ ID NO:17, SEQ ID NO:19, SEQ ID NO:20, SEQ ID NO:22, SEQ ID

NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45, and/or a nucleic acid sequence encoding a protein comprising the amino acid sequence SEQ ID NO:33 and a complement thereof.

Additional preferred nucleic acid molecules of the present invention include fragments of

- 5 an isolated nucleic acid molecule comprising at least about 150 base-pairs, wherein said nucleic acid molecule hybridizes, in a solution comprising 1X SSC and 0% formamide, at a temperature of about 50°C, to a nucleic acid sequence selected from the group consisting of SEQ ID NO:14, SEQ ID NO:16, SEQ ID NO:17, SEQ ID NO:19, SEQ ID NO:20, SEQ ID NO:22, SEQ ID NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45 and a nucleic acid sequence encoding a protein comprising the amino acid sequence SEQ ID NO:33 and complement thereof.

Additional preferred *Der* HMW-map nucleic acid molecules of the present invention include an isolated nucleic acid molecule which is at least about 50 nucleotides, or at least about 150 nucleotides, comprising a nucleic acid sequence that is preferably at least about 60% identical, more preferably at least about 65% identical, more preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably at least about 85% identical, more preferably at least about 90% identical and even more preferably at least about 95% identical to a nucleic acid sequence selected from the group consisting of SEQ ID NO:14, SEQ ID NO:16, SEQ ID NO:17, SEQ ID NO:19, SEQ ID NO:20, SEQ ID NO:22, SEQ ID NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45, and a nucleic acid sequence encoding a protein

comprising the amino acid sequence SEQ ID NO:33 and a complement thereof. Also preferred are fragments of any of such nucleic acid molecules. Percent identity may be determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

5 One embodiment of the present invention is a nucleic acid molecule comprising all or part of nucleic acid molecules nDerf98₁₇₅₂, nDerf98₁₆₆₅ and nDerf98₁₆₀₈, nDerf98₁₆₂₁, nDerf98₁₅₂₇, nDerf98₁₄₇₀, and/or nDerf60₅₁₀, or allelic variants of these nucleic acid molecules. Another preferred nucleic acid molecule of the present invention includes at least a portion of nucleic acid sequence SEQ ID NO:14, SEQ ID NO:16, SEQ ID NO:17, SEQ ID NO:19, SEQ ID NO:20, SEQ ID NO:22, SEQ ID NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45 and/or a nucleic acid sequence encoding a protein comprising the amino acid sequence SEQ ID NO:33, as well as allelic variants of nucleic acid molecules having these nucleic acid sequences and homologs of nucleic acid molecules having these nucleic acid sequences; preferably such a homolog encodes or is complementary to a nucleic acid molecule that encodes at least one epitope that elicits and an immune response against a protein having an amino acid sequence SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:18 , SEQ ID NO:21, SEQ ID NO:23, SEQ ID NO:24, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:35, SEQ ID NO:38, SEQ ID NO:41, SEQ ID NO:41, and/or SEQ ID NO:44. Such nucleic acid molecules can include nucleotides in addition to those included in the SEQ

ID NOs, such as, but not limited to, a full-length gene, a full-length coding region, a nucleic acid molecule encoding a fusion protein, or a nucleic acid molecule encoding a multivalent protective compound.

In one embodiment, a *Der* HMW-map nucleic acid molecule of the present invention encodes a protein that is at least about 45%, preferably at least about 50%, more preferably at least about 55%, even more preferably at least about 60%, even more preferably at least about 65%, even more preferably at least about 70%, even more preferably at least about 75%, even more preferably at least about 80%, even more preferably at least about 85%, even more preferably at least about 90%, and even more preferably about 95% identical to PDerf98₅₅₅, PDerp98₅₀₉, and/or PDerf60₁₇₀. Even more preferred is a nucleic acid molecule encoding PDerf98₅₅₅, PDerf98₅₃₆, PDerp98₅₀₉, PDerp98₄₉₀, and/or PDerf60₁₇₀, and/or an allelic variant of such nucleic acid molecules.

In another embodiment, a *Der* HMW-map nucleic acid molecule of the present invention encodes a protein having an amino acid sequence that is at least about 45%, preferably at least about 50%, more preferably at least about 55%, even more preferably at least about 60%, even more preferably at least about 65%, even more preferably at least about 70%, even more preferably at least about 75%, even more preferably at least about 80%, even more preferably at least about 85%, even more preferably at least about 90%, and even more preferably about 95% identical to SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:18, SEQ ID NO:21, SEQ ID NO:23, SEQ ID NO:24, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID

NO:35, SEQ ID NO:38, SEQ ID NO:41, SEQ ID NO:41, and/or SEQ ID NO:44. The present invention also includes a *Der* HMW-map nucleic acid molecule encoding a protein having at least a portion of SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ
5 ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:18 , SEQ ID NO:21, SEQ ID NO:23, SEQ ID NO:24, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:35, SEQ ID NO:38, SEQ ID NO:41, SEQ ID NO:41, and/or SEQ ID NO:44, as well as allelic variants
10 of a *Der* HMW-map nucleic acid molecule encoding a protein having these sequences, including nucleic acid molecules that have been modified to accommodate codon usage properties of the cells in which such nucleic acid molecules are to be expressed.
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In another embodiment, a preferred *Der* HMW-map nucleic acid molecule encodes a *Der* HMW-map protein comprising at least about at least about 35 amino acids in length, preferably at least about 50 amino acids in length, more preferably at least about 100 amino acids in length, more preferably at least about 200 amino acids in length, even more preferably at least about 250 amino acids in length.

Knowing the nucleic acid sequences of certain *Der* HMW-map nucleic acid molecules of the present invention allows one skilled in the art to, for example, (a) make copies of those nucleic acid molecules, (b) obtain nucleic acid molecules including at least a portion of such nucleic acid molecules (e.g., nucleic acid molecules including full-length genes, full-length coding regions, regulatory control sequences, truncated coding regions), and (c) obtain other *Der* HMW-map nucleic acid molecules. Such nucleic acid molecules can be obtained in a variety of ways including screening appropriate
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expression libraries with antibodies of the present invention; traditional cloning techniques using oligonucleotide probes of the present invention to screen appropriate libraries; and PCR amplification of appropriate libraries or DNA using oligonucleotide primers of the present invention. A preferred library to screen or from which to amplify nucleic acid molecules includes a *Dermatophagoides farinae* and/or *Dermatophagoides pteronyssus* library, such as the libraries disclosed herein in the Examples. Techniques to clone and amplify genes are disclosed, for example, in Sambrook et al., *ibid.*

The present invention also includes nucleic acid molecules that are oligonucleotides capable of hybridizing, under stringent hybridization conditions, with complementary regions of other, preferably longer, nucleic acid molecules of the present invention such as those comprising *Der* HMW-map nucleic acid molecules or other *Der* HMW-map nucleic acid molecules. Oligonucleotides of the present invention can be RNA, DNA, or derivatives of either. The minimum size of such oligonucleotides is the size required for formation of a stable hybrid between an oligonucleotide and a complementary sequence on a nucleic acid molecule of the present invention. A preferred oligonucleotide of the present invention has a maximum size of preferably about 200 nucleotides, more preferably about 150 nucleotides and even more preferably about 100 nucleotides. The present invention includes oligonucleotides that can be used as, for example, probes to identify nucleic acid molecules.

One embodiment of the present invention includes a recombinant vector, which includes at least one isolated nucleic acid molecule of the present invention, inserted into any vector capable of delivering the nucleic acid molecule into a host cell. Such a vector contains heterologous nucleic acid sequences, that is nucleic acid sequences that are not

naturally found adjacent to nucleic acid molecules of the present invention and that preferably are derived from a species other than the species from which the nucleic acid molecule(s) are derived. The vector can be either RNA or DNA, either prokaryotic or eukaryotic, and typically is a virus or a plasmid. Recombinant vectors can be used in the cloning, sequencing, and/or otherwise manipulation of *Der* HMW-map nucleic acid molecules of the present invention.

One type of recombinant vector, referred to herein as a recombinant molecule, comprises a nucleic acid molecule of the present invention operatively linked to an expression vector. The phrase operatively linked refers to insertion of a nucleic acid molecule into an expression vector in a manner such that the molecule is able to be expressed when transformed into a host cell. As used herein, an expression vector is a DNA or RNA vector that is capable of transforming a host cell and of effecting expression of a specified nucleic acid molecule. Preferably, the expression vector is also capable of replicating within the host cell. Expression vectors can be either prokaryotic or eukaryotic, and are typically viruses or plasmids. Expression vectors of the present invention include any vectors that function (i.e., direct gene expression) in recombinant cells of the present invention, including in bacterial, fungal, endoparasite, insect, other animal, and plant cells. Preferred expression vectors of the present invention can direct gene expression in bacterial, yeast, insect and mammalian cells and more preferably in the cell types disclosed herein.

In particular, expression vectors of the present invention contain regulatory sequences such as transcription control sequences, translation control sequences, origins of replication, and other regulatory sequences that are compatible with the recombinant

cell and that control the expression of nucleic acid molecules of the present invention. In particular, recombinant molecules of the present invention include transcription control sequences. Transcription control sequences are sequences which control the initiation, elongation, and termination of transcription. Particularly important transcription control sequences are those which control transcription initiation, such as promoter, enhancer, operator and repressor sequences. Suitable transcription control sequences include any transcription control sequence that can function in at least one of the recombinant cells of the present invention. A variety of such transcription control sequences are known to those skilled in the art. Preferred transcription control sequences include those which function in bacterial, yeast, insect and mammalian cells, such as, but not limited to, *tac*, *lac*, *trp*, *trc*, oxy-pro, *omp/lpp*, *rrnB*, bacteriophage lambda (such as lambda p_L and lambda p_R and fusions that include such promoters), bacteriophage T7, T7*lac*, bacteriophage T3, bacteriophage SP6, bacteriophage SP01, metallothionein, alpha-mating factor, *Pichia* alcohol oxidase, alphavirus subgenomic promoters (such as Sindbis virus subgenomic promoters), antibiotic resistance gene, baculovirus, *Heliothis zea* insect virus, vaccinia virus, herpesvirus, raccoon poxvirus, other poxvirus, adenovirus, cytomegalovirus (such as intermediate early promoters), simian virus 40, retrovirus, actin, retroviral long terminal repeat, Rous sarcoma virus, heat shock, phosphate and nitrate transcription control sequences as well as other sequences capable of controlling gene expression in prokaryotic or eukaryotic cells. Additional suitable transcription control sequences include tissue-specific promoters and enhancers as well as lymphokine-inducible promoters (e.g., promoters inducible by interferons or interleukins).

Transcription control sequences of the present invention can also include naturally occurring transcription control sequences naturally associated with canines or felines.

Suitable and preferred nucleic acid molecules to include in recombinant vectors of the present invention are as disclosed herein. Preferred nucleic acid molecules to include in recombinant vectors, and particularly in recombinant molecules, include nDerf98₁₇₅₂, 5 nDerf98₁₆₆₅ nDerf98₁₆₀₈, nDerp98₁₆₂₁, nDerp98₁₅₂₇, nDerp98₁₄₇₀, and nDerf60₅₁₀.

Recombinant molecules of the present invention may also (a) contain secretory signals (i.e., signal segment nucleic acid sequences) to enable an expressed *Der* HMW-map protein of the present invention to be secreted from the cell that produces the protein and/or (b) contain fusion sequences which lead to the expression of nucleic acid 10 molecules of the present invention as fusion proteins. Examples of suitable signal segments include any signal segment capable of directing the secretion of a protein of the present invention. Preferred signal segments include, but are not limited to, tissue plasminogen activator (t-PA), interferon, interleukin, growth hormone, histocompatibility and viral envelope glycoprotein signal segments, as well as natural signal segments. 15

Suitable fusion segments encoded by fusion segment nucleic acids are disclosed herein.

In addition, a nucleic acid molecule of the present invention can be joined to a fusion segment that directs the encoded protein to the proteosome, such as a ubiquitin fusion segment. Recombinant molecules may also include intervening and/or untranslated 20 sequences surrounding and/or within the nucleic acid sequences of nucleic acid molecules of the present invention.

Another embodiment of the present invention includes a recombinant cell comprising a host cell transformed with one or more recombinant molecules of the

present invention. Transformation of a nucleic acid molecule into a cell can be accomplished by any method by which a nucleic acid molecule can be inserted into the cell. Transformation techniques include, but are not limited to, transfection, electroporation, microinjection, lipofection, adsorption, and protoplast fusion. A recombinant cell may remain unicellular or may grow into a tissue, organ or a multicellular organism. Transformed nucleic acid molecules of the present invention can remain extrachromosomal or can integrate into one or more sites within a chromosome of the transformed (i.e., recombinant) cell in such a manner that their ability to be expressed is retained. Preferred nucleic acid molecules with which to transform a cell include *Der* HMW-map nucleic acid molecules disclosed herein. Particularly preferred nucleic acid molecules with which to transform a cell include nDerf98₁₇₅₂, nDerf98₁₆₆₅, nDerf98₁₆₀₈, nDerp98₁₆₂₁, nDerp98₁₅₂₇, nDerp98₁₄₇₀, and nDerf60₅₁₀.

Suitable host cells to transform include any cell that can be transformed with a nucleic acid molecule of the present invention. Host cells can be either untransformed cells or cells that are already transformed with at least one nucleic acid molecule (e.g., nucleic acid molecules encoding one or more proteins of the present invention and/or other proteins useful in the production of multivalent vaccines). Host cells of the present invention either can be endogenously (i.e., naturally) capable of producing *Der* HMW-map proteins of the present invention or can be capable of producing such proteins after being transformed with at least one nucleic acid molecule of the present invention. Host cells of the present invention can be any cell capable of producing at least one protein of the present invention, and include bacterial, fungal (including yeast), other insect, other animal and plant cells. Preferred host cells include bacterial, mycobacterial, yeast,

parasite, insect and mammalian cells. More preferred host cells include *Salmonella*, *Escherichia*, *Bacillus*, *Listeria*, *Saccharomyces*, *Spodoptera*, *Mycobacteria*, *Trichoplusia*, BHK (baby hamster kidney) cells, MDCK cells (normal dog kidney cell line for canine herpesvirus cultivation), CRFK cells (normal cat kidney cell line for feline herpesvirus cultivation), CV-1 cells (African monkey kidney cell line used, for example, to culture raccoon poxvirus), COS (e.g., COS-7) cells, and Vero cells. Particularly preferred host cells are *Escherichia coli*, including *E. coli* K-12 derivatives; *Salmonella typhi*; *Salmonella typhimurium*, including attenuated strains such as UK-1 x3987 and SR-11 x4072; *Spodoptera frugiperda*; *Trichoplusia ni*; BHK cells; MDCK cells; CRFK cells; CV-1 cells; COS cells; Vero cells; and non-tumorigenic mouse myoblast G8 cells (e.g., ATCC CRL 1246). Additional appropriate mammalian cell hosts include other kidney cell lines, other fibroblast cell lines (e.g., human, murine or chicken embryo fibroblast cell lines), myeloma cell lines, Chinese hamster ovary cells, mouse NIH/3T3 cells, LMTK³¹ cells and/or HeLa cells.

A recombinant cell is preferably produced by transforming a host cell with one or more recombinant molecules, each comprising one or more nucleic acid molecules of the present invention operatively linked to an expression vector containing one or more transcription control sequences. The phrase operatively linked refers to insertion of a nucleic acid molecule into an expression vector in a manner such that the molecule is able to be expressed when transformed into a host cell.

A recombinant molecule of the present invention is a molecule that can include at least one of any nucleic acid molecule heretofore described operatively linked to at least one of any transcription control sequence capable of effectively regulating expression of

the nucleic acid molecule(s) in the cell to be transformed, examples of which are disclosed herein.

A recombinant cell of the present invention includes any cell transformed with at least one of any *Der* HMW-map nucleic acid molecule of the present invention. Suitable and preferred *Der* HMW-map nucleic acid molecules as well as suitable and preferred recombinant molecules with which to transform cells are disclosed herein.

Recombinant DNA technologies can be used to improve expression of transformed nucleic acid molecules by manipulating, for example, the number of copies of the nucleic acid molecules within a host cell, the efficiency with which those nucleic acid molecules are transcribed, the efficiency with which the resultant transcripts are translated, and the efficiency of post-translational modifications. Recombinant techniques useful for increasing the expression of nucleic acid molecules of the present invention include, but are not limited to, operatively linking nucleic acid molecules to high-copy number plasmids, integration of the nucleic acid molecules into one or more host cell chromosomes, addition of vector stability sequences to plasmids, substitutions or modifications of transcription control signals (e.g., promoters, operators, enhancers), substitutions or modifications of translational control signals (e.g., ribosome binding sites, Shine-Dalgarno sequences), modification of nucleic acid molecules of the present invention to correspond to the codon usage of the host cell, deletion of sequences that destabilize transcripts, and use of control signals that temporally separate recombinant cell growth from recombinant enzyme production during fermentation. The activity of an expressed recombinant protein of the present invention may be improved by fragmenting, modifying, or derivatizing nucleic acid molecules encoding such a protein.

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Isolated *Der* HMW-map proteins of the present invention can be produced in a variety of ways, including production and recovery of natural proteins, production and recovery of recombinant proteins, and chemical synthesis of the proteins. In one embodiment, an isolated protein of the present invention is produced by culturing a cell capable of expressing the protein under conditions effective to produce the protein, and recovering the protein. A preferred cell to culture is a recombinant cell of the present invention. Effective culture conditions include, but are not limited to, effective media, bioreactor, temperature, pH and oxygen conditions that permit protein production. An effective medium refers to any medium in which a cell is cultured to produce a *Der* HMW-map protein of the present invention. Such a medium typically comprises an aqueous medium having assimilable carbon, nitrogen and phosphate sources, and appropriate salts, minerals, metals and other nutrients, such as vitamins. Cells of the present invention can be cultured in conventional fermentation bioreactors, shake flasks, test tubes, microtiter dishes, and petri plates. Culturing can be carried out at a temperature, pH and oxygen content appropriate for a recombinant cell. Such culturing conditions are within the expertise of one of ordinary skill in the art.

Depending on the vector and host system used for production, resultant proteins of the present invention may either remain within the recombinant cell; be secreted into the fermentation medium; be secreted into a space between two cellular membranes, such as the periplasmic space in *E. coli*; or be retained on the outer surface of a cell or viral membrane. The phrase "recovering the protein", as well as similar phrases, refers to collecting the whole fermentation medium containing the protein and need not imply additional steps of separation or purification. Proteins of the present invention can be

purified using a variety of standard protein purification techniques, such as, but not limited to, affinity chromatography, ion exchange chromatography, filtration, electrophoresis, hydrophobic interaction chromatography, gel filtration chromatography, reverse phase chromatography, concanavalin A chromatography, chromatofocusing and differential solubilization. Proteins of the present invention are preferably retrieved in "substantially pure" form. As used herein, "substantially pure" refers to a purity that allows for the effective use of the protein as a therapeutic composition or diagnostic. A therapeutic composition for animals, for example, should exhibit no substantial toxicity and preferably should be capable of desensitizing a treated animal.

The present invention also includes isolated (i.e., removed from their natural milieu) antibodies that selectively bind to a *Der* HMW-map protein of the present invention or a mimotope thereof (i.e., anti-*Der* HMW-map protein antibodies). As used herein, the term "selectively binds to" a *Der* HMW-map protein refers to the ability of antibodies of the present invention to preferentially bind to specified proteins and mimotopes thereof of the present invention. Binding can be measured using a variety of methods standard in the art including enzyme immunoassays (e.g., ELISA), immunoblot assays, etc.; see, for example, Sambrook et al., *ibid*. An anti-*Der* HMW-map protein antibody preferably selectively binds to a portion of a *Der* HMW-map protein that induces an immune response in an animal.

Isolated antibodies of the present invention can include antibodies in a bodily fluid (such as, but not limited to, serum), or antibodies that have been purified to varying degrees. Antibodies of the present invention can be polyclonal or monoclonal. Functional equivalents of such antibodies, such as antibody fragments and genetically-

engineered antibodies (including single chain antibodies or chimeric antibodies that can bind to more than one epitope) are also included in the present invention.

A preferred method to produce antibodies of the present invention includes (a) administering to an animal an effective amount of a protein, peptide or mimotope thereof of the present invention to produce the antibodies and (b) recovering the antibodies. In another method, antibodies of the present invention are produced recombinantly using techniques as heretofore disclosed to produce *Der* HMW-map proteins of the present invention. Antibodies raised against defined proteins or mimotopes can be advantageous because such antibodies are not substantially contaminated with antibodies against other substances that might otherwise cause interference in a diagnostic assay or side effects if used in a therapeutic composition.

Antibodies of the present invention have a variety of potential uses that are within the scope of the present invention. For example, such antibodies can be used (a) as tools to detect mite allergen, in particular *Der* HMW-map protein; (b) as tools to screen expression libraries; and/or (c) to recover desired proteins of the present invention from a mixture of proteins and other contaminants. Antibodies of the present invention can also be used, for example, to inhibit binding of *Der* HMW-map protein to IgE that binds specifically to *Der* HMW-map protein, to prevent immunocomplex formation, thereby reducing hypersensitivity responses to mite allergens.

A *Der* HMW-map protein of the present invention can be included in a chimeric molecule comprising at least a portion of a *Der* HMW-map protein that induces an immune response in an animal and a second molecule that enables the chimeric molecule to be bound to a substrate in such a manner that the *Der* HMW-map protein portion can

bind to IgE in essentially the same manner as a *Der* HMW-map protein that is not bound to a substrate. An example of a suitable second molecule includes a portion of an immunoglobulin molecule or another ligand that has a suitable binding partner that can be immobilized on a substrate, e.g., biotin and avidin, or a metal-binding protein and a metal (e.g., His), or a sugar-binding protein and a sugar (e.g., maltose).

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A *Der* HMW-map protein of the present invention can be contained in a formulation, herein referred to as a *Der* HMW-map protein formulation. For example, a *Der* HMW-map protein can be combined with a buffer in which the *Der* HMW-map protein is solubilized, and/or with a carrier. Suitable buffers and carriers are known to those skilled in the art. Examples of suitable buffers include any buffer in which a *Der* HMW-map protein can function to selectively bind to an antibody that specifically binds to *Der* HMW-map protein, such as, but not limited to, phosphate buffered saline, water, saline, phosphate buffer, bicarbonate buffer, HEPES buffer (N-2-hydroxyethylpiperazine-N'-2-ethanesulfonic acid buffered saline), TES buffer (Tris-EDTA buffered saline), Tris buffer and TAE buffer (Tris-acetate-EDTA). Examples of carriers include, but are not limited to, polymeric matrices, toxoids, and serum albumins, such as bovine serum albumin. Carriers can be mixed with *Der* HMW-map protein or conjugated (i.e., attached) to *Der* HMW-map protein in such a manner as to not substantially interfere with the ability of the *Der* HMW-map protein to selectively bind to an antibody that specifically binds to *Der* HMW-map protein.

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A *Der* HMW-map protein of the present invention can be produced by a cell comprising the *Der* HMW-map protein. A preferred *Der* HMW-map protein-bearing cell

includes a recombinant cell comprising a nucleic acid molecule encoding a *Der* HMW-map protein of the present invention.

In addition, a *Der* HMW-map protein formulation of the present invention can include not only a *Der* HMW-map protein but also one or more additional antigens or antibodies useful in desensitizing an animal against allergy, or preventing or treating mite allergen pathogenesis. As used herein, an antigen refers to any molecule capable of being selectively bound by an antibody. As used herein, an allergen refers to any antigen that is capable of stimulating production of antibodies involved in an allergic response in an animal. As used herein, selective binding of a first molecule to a second molecule refers to the ability of the first molecule to preferentially bind (e.g., having higher affinity higher avidity) to the second molecule when compared to the ability of a first molecule to bind to a third molecule. The first molecule need not necessarily be the natural ligand of the second molecule. Allergens of the present invention are preferably derived from mites, and mite-related allergens including, but not limited to, other insect allergens and plant allergens.

In accordance with the present invention, virtually any substance can act as an antigen and elicit an antibody response, i.e., can function as an epitope. For example, antibodies can be raised in response to carbohydrate epitopes, including saccharides and/or polysaccharides that are attached to a protein, a so-called glycosylated protein.

However, a saccharide and/or polysaccharide may act as an antigen alone, without a protein being present. The terminal sugar of a carbohydrate moiety, as well as internal sugars can serve as an epitope. Polysaccharide may be present as a branched chain, in which case epitopes may comprise sugars that are not contiguous in sequence, but are

adjacent spatially. Unusual, insect-specific sugars, not normally seen in mammalian proteins, may be present on glycoprotein derived from insect nucleic acid molecules, and these unusual sugars can comprise an epitope recognized by a mammalian immune system.

5 One embodiment of the present invention is a reagent comprising a non-proteinaceous epitope that is capable of binding to IgE of an animal that is allergic to mites, of desensitizing an animal against mite allergen, of stimulating a B lymphocyte response, and/or of stimulating a T lymphocyte response. Such an epitope, referred to herein as a *Der* NP epitope, can exist as part of a *Der* HMW-map protein of the present invention or can be isolated therefrom. Such an epitope exists, for example, on a protein contained in the *D. farinae* HMW-map composition produced in accordance with Example 1. A *Der* NP epitope of the present invention can be isolated from its natural source or produced synthetically. Such an epitope can be, but need not be, joined to a carrier or other molecule. A *Der* NP epitope has at least one of the following identifying characteristics: (a) the epitope is resistant to β -elimination of peptides; (b) the epitope is resistant to Proteinase-K digestion; and (c) the epitope is reactive to a test designed to detect glycosylated proteins. A preferred *Der* NP epitope has all such identifying characteristics. A *Der* NP epitope can selectively bind to IgE of dogs or cats that are allergic to mites. While not being bound by theory, it is believed that a *Der* NP epitope comprises a carbohydrate moiety that apparently does not include an N-linked glycan. Identification of the structural characteristics of such an epitope can be determined by one skilled in the art. In one embodiment, there is provided an isolated antibody that selectively binds to a *Der* NP epitope. The present invention also includes a derivative of

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a *Der NP* epitope, i.e., a compound that mimics the activity of such an epitope (e.g. is a *Der NP* epitope mimetope) and is capable of binding to antibody raised against a native (i.e. seen in nature) *Der NP* epitope.

A reagent comprising a *Der NP* epitope of the present invention can be used in a variety of ways in accordance with the present invention. Such a reagent can be a desensitizing compound or a detection reagent to test for mite allergy susceptibility or sensitivity. In one embodiment, a therapeutic composition of the present invention includes a reagent comprising a *Der NP* epitope. In another embodiment, an assay kit of the present invention includes a reagent comprising a *Der NP* epitope. One embodiment of the present invention is a method to identify an animal susceptible to or having an allergic response to a mite. Such a method includes the steps of contacting a reagent comprising a *Der NP* epitope with antibodies of an animal and determining immunocomplex formation between the reagent and the antibodies, wherein formation of the immunocomplex indicates that the animal is susceptible to or has said allergic response. Another embodiment of the present invention is a method to desensitize a host animal to an allergic response to a mite. Such a method includes the step of administering to the animal a therapeutic composition that includes a reagent comprising a *Der NP* epitope as a desensitizing compound.

Another embodiment of the present invention is a *Der HMW-map* protein lacking *Der NP* epitopes. Without being bound by theory, it is believed that such a protein would be a better desensitizing compound since such a protein is expected to have a reduced ability to bind to IgE. Such a protein can be produced by, for example, removing *Der NP*

epitopes from a native *Der* HMW-map protein or by producing the protein recombinantly, for example in *E. coli*.

One embodiment of the present invention is an *in vivo* test that is capable of detecting whether an animal is hypersensitive to *Der* HMW-map protein. An *in vivo* hypersensitivity test of the present invention is particularly useful for identifying animals susceptible to or having allergy to mite allergens. A suitable *in vivo* hypersensitivity test of the present invention can be, but is not limited to, a skin test comprising administering (e.g., intradermally injecting or superficial scratching) an effective amount of a formulation containing *Der* HMW-map protein, or a mimotope thereof. Methods to conduct skin tests of the present invention are known to those of skill in the art and are briefly disclosed herein.

Suitable formulations to use in an *in vivo* skin test include *Der* HMW-map protein, homologs of *Der* HMW-map protein and/or mimotopes of *Der* HMW-map protein.

It is understood by one of skill in the art that a suitable amount of *Der* HMW-map protein formulation for use in a skin test of the present invention can vary widely depending on the allergenicity of the formulation used in the test and on the site at which the product is delivered. Suitable amounts of *Der* HMW-map protein formulation for use in a skin test of the present invention include an amount capable of forming reaction, such as a detectable wheal or induration (hardness) resulting from an allergic reaction to the formulation. Preferred amounts of *Der* HMW-map protein for use in a skin test of the present invention range from about 1×10^8 micrograms (μg) to about 100 μg , more preferably from about 1×10^7 μg to about 10 μg , and even more preferably from about 1

x 10⁻⁶ µg to about 1 µg of *Der* HMW-map protein. It is to be appreciated by those of skill in the art that such amounts will vary depending upon the allergenicity of the protein being administered.

According to the present invention, *Der* HMW-map protein of the present invention can be combined with an immunopotentiator (e.g., carriers or adjuvants of the present invention as defined in detail below). A novel aspect, however, of the present invention is that *Der* HMW-map protein of the present invention can induce a hypersensitive response in the absence of an immunopotentiator, particularly in canines.

A skin test of the present invention further comprises administering a control solution to an animal. A control solution can include a negative control solution and/or a positive control solution. A positive control solution of the present invention contains an effective amount of at least one compound known to induce a hypersensitive response when administered to an animal. A preferred compound for use as positive control solution includes, but is not limited to, histamine. A negative control solution of the present invention can comprise a solution that is known not to induce a hypersensitive response when administered to an animal. As such, a negative control solution can comprise a solution having compounds essentially incapable of inducing a hypersensitive response or simply a buffer used to prepare the formulation, such as saline. An example of a preferred negative control solution is phenolated phosphate buffered saline (available from Greer Laboratories, Inc., Lenoir, NC).

Hypersensitivity of an animal to one or more formulations of the present invention can be evaluated by measuring reactions (e.g., wheal size, induration or hardness; using techniques known to those skilled in the art) resulting from

administration of one or more experimental sample(s) and control sample(s) into an animal and comparing the reactions to the experimental sample(s) with reactions resulting from administration of one or more control solution. Preferred devices for intradermal injections include individual syringes. Preferred devices for scratching include devices that permit the administration of a number of samples at one time. The hypersensitivity of an animal can be evaluated by determining if the reaction resulting from administration of a formulation of the present invention is larger than the reaction resulting from administration of a negative control, and/or by determining if the reaction resulting from administration of the formulation is at least about the same size as the reaction resulting from administration of a positive control solution. As such, if an experimental sample produces a reaction greater than or equal to the size of a wheal produced by administration of a positive control sample to an animal, then that animal is hypersensitive to the experimental sample. Conversely, if an experimental sample produces a reaction similar to the reaction produced by administration of a negative control sample to an animal, then that animal is not hypersensitive to the experimental sample.

Preferred wheal sizes for evaluation of the hypersensitivity of an animal range from about 16 mm to about 8 mm, more preferably from about 15 mm to about 9 mm, and even more preferably from about 14 mm to about 10 mm in diameter.

Preferably, the ability or inability of an animal to exhibit an immediate hypersensitive response to a formulation of the present invention is determined by measuring wheal sizes from about 2 minutes to about 30 minutes after administration of a

sample, more preferably from about 10 minutes to about 25 minutes after administration of a sample, and even more preferably about 15 minutes after administration of a sample.

Preferably, the ability or inability of an animal to exhibit a delayed hypersensitive response to a formulation of the present invention is determined by measuring induration and/or erythema from about 18 hours to about 30 hours after administration of a sample, more preferably from about 20 hours to about 28 hours after administration of a sample, and even more preferably at about 24 hours after administration of a sample. A delayed hypersensitivity response can also be measured using other techniques such as by determining, using techniques known to those of skill in the art, the extent of cell infiltrate at the site of administration during the time periods defined directly above.

In a preferred embodiment, a skin test of the present invention comprises intradermally injecting into an animal at a given site an effective amount of a formulation that includes *Der* HMW-map protein, and intradermally injecting an effective amount of a control solution into the same animal at a different site. It is within the scope of one of skill in the art to use devices capable of delivering multiple samples simultaneously at a number of sites, preferably enabling concurrent evaluation of numerous formulations. A preferred *Der* HMW-map protein for use with a skin test includes full-length protein. A preferred positive control sample can be a sample comprising histamine. A preferred negative control sample can be a sample comprising diluent.

Animals suitable and preferred to test for hypersensitivity to *Der* HMW-map protein using a skin test of the present invention are disclosed herein. Particularly preferred animals to test with a skin test of the present invention include humans, canines, felines and equines, with human, canines and felines being even more preferred. As used

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herein, canine refers to any member of the dog family, including domestic dogs, wild dogs and zoo dogs. Examples of dogs include, but are not limited to, domestic dogs, wild dogs, foxes, wolves, jackals and coyotes. As used herein, feline refers to any member of the cat family, including domestic cats, wild cats and zoo cats. Examples of cats include, but are not limited to, domestic cats, lions, tigers, leopards, panthers, cougars, bobcats, lynx, jaguars, cheetahs and servals. As used herein, equine refers to any member of the horse family, including horses, donkeys, mules and zebras.

One embodiment of the present invention is a method to detect antibodies *in vitro* that bind to *Der* HMW-map protein (referred to herein as anti-*Der* HMW-map antibody)

10 which includes the steps of: (a) contacting an isolated *Der* HMW-map protein with a putative anti-*Der* HMW-map antibody-containing composition under conditions suitable for formation of a *Der* HMW-map protein:antibody complex; and (b) detecting the presence of the antibody by detecting the *Der* HMW-map protein:antibody complex.

15 Presence of such a *Der* HMW-map protein:antibody complex indicates that the animal is producing antibody to a mite allergen. Preferred anti-*Der* HMW-map antibody to detect include antibodies having an IgE or IgG isotype. Preferred anti-*Der* HMW-map antibody to detect include feline antibody, canine antibody, equine antibody and human antibody, with feline, canine and human antibody being particularly preferred.

20 As used herein, the term "contacting" refers to combining or mixing, in this case a putative antibody-containing composition with a *Der* HMW-map protein. Formation of a complex between a *Der* HMW-map protein and an antibody refers to the ability of the *Der* HMW-map protein to selectively bind to the antibody in order to form a stable complex that can be measured (i.e., detected). As used herein, the term selectively binds

to an antibody refers to the ability of a *Der* HMW-map protein of the present invention to preferentially bind to an antibody, without being able to substantially bind to other antibodies that do not specifically bind to *Der* HMW-map protein. Binding between a *Der* HMW-map protein and an antibody is effected under conditions suitable to form a complex; such conditions (e.g., appropriate concentrations, buffers, temperatures, reaction times) as well as methods to optimize such conditions are known to those skilled in the art, and examples are disclosed herein. Examples of complex formation conditions are also disclosed in, for example, in Sambrook et al., *ibid.*

As used herein, the term "detecting complex formation" refers to determining if any complex is formed, i.e., assaying for the presence (i.e., existence) of a complex. If complexes are formed, the amount of complexes formed can, but need not be, determined. Complex formation, or selective binding, between *Der* HMW-map protein and an antibody in the composition can be measured (i.e., detected, determined) using a variety of methods standard in the art (see, for example, Sambrook et al. *ibid.*), examples of which are disclosed herein.

In one embodiment, a putative antibody-containing composition of the present method includes a biological sample from an animal. A suitable biological sample includes, but is not limited to, a bodily fluid composition or a cellular composition. A bodily fluid refers to any fluid that can be collected (i.e., obtained) from an animal, examples of which include, but are not limited to, blood, serum, plasma, urine, tears, aqueous humor, cerebrospinal fluid (CSF), saliva, lymph, nasal secretions, milk and feces. Such a composition of the present method can, but need not be, pretreated to remove at least some of the non-IgE or non-IgG isotypes of immunoglobulin and/or other

proteins, such as albumin, present in the fluid. Such removal can include, but is not limited to, contacting the bodily fluid with a material, such as the lectin jacalin or an antibody that specifically binds to the constant region of an IgA immunoglobulin (i.e., anti-IgA isotype antibody), to remove IgA antibodies and/or affinity purifying IgE or IgG antibodies from other components of the body fluid by exposing the fluid to, for example, Concanavalin A or protein G, respectively. In another embodiment, a composition includes collected bodily fluid that is pretreated to concentrate immunoglobulin contained in the fluid. For example, immunoglobulin contained in a bodily fluid can be precipitated from other proteins using ammonium sulfate. A preferred composition of the present method is serum.

In another embodiment, an antibody-containing composition of the present method includes a cell that produces IgE or IgG. Such a cell can have IgE or IgG bound to the surface of the cell and/or can secrete IgE or IgG. An example of such a cell includes myeloma cells. IgE or IgG can be bound to the surface of a cell either directly to the membrane of the cell or bound to a molecule (e.g., an antigen) bound to the surface of the cell.

A complex can be detected in a variety of ways including, but not limited to use of one or more of the following assays: an enzyme-linked immunoassay, a radioimmunoassay, a fluorescence immunoassay, a chemiluminescent assay, a lateral flow assay, an agglutination assay, a particulate-based assay (e.g., using particulates such as, but not limited to, magnetic particles or plastic polymers, such as latex or polystyrene beads), an immunoprecipitation assay, a BioCore™ assay (e.g., using colloidal gold) and an immunoblotting assay (e.g., a western blot). Such assays are well known to those

skilled in the art. Assays can be used to give qualitative or quantitative results depending on how they are used. Some assays, such as agglutination, particulate separation, and immunoprecipitation, can be observed visually (e.g., either by eye or by a machines, such as a densitometer or spectrophotometer) without the need for a detectable marker.

5 In other assays, conjugation (i.e., attachment) of a detectable marker to the *Der* HMW-map protein, to antibody bound to the *Der* HMW-map protein, or to a reagent that selectively binds to the *Der* HMW-map protein or to the antibody bound to the *Der* HMW-map protein (described in more detail below) aids in detecting complex formation. Examples of detectable markers include, but are not limited to, a radioactive label, an
10 enzyme, a fluorescent label, a chemiluminescent label, a chromophoric label or a ligand. A ligand refers to a molecule that binds selectively to another molecule. Preferred detectable markers include, but are not limited to, fluorescein, a radioisotope, a phosphatase (e.g., alkaline phosphatase), biotin, avidin, a peroxidase (e.g., horseradish peroxidase) and biotin-related compounds or avidin-related compounds (e.g., streptavidin
15 or ImmunoPure® NeutrAvidin available from Pierce, Rockford, IL).

In one embodiment, a complex is detected by contacting a putative antibody-containing composition with a *Der* HMW-map protein that is conjugated to a detectable marker. A suitable detectable marker to conjugate to a *Der* HMW-map protein includes, but is not limited to, a radioactive label, a fluorescent label, an enzyme label, a
20 chemiluminescent label, a chromophoric label or a ligand. A detectable marker is conjugated to a *Der* HMW-map protein in such a manner as not to block the ability of the *Der* HMW-map protein to bind to the antibody being detected.

In another embodiment, a *Der* HMW-map protein:antibody complex is detected by contacting a putative antibody-containing composition with a *Der* HMW-map protein and then contacting the complex with an indicator molecule. Suitable indicator molecules of the present invention include molecules that can bind to either the *Der* HMW-map protein or to the antibody bound to the *Der* HMW-map protein. As such, an indicator molecule can comprise, for example, an antigen and an antibody, depending upon which portion of the *Der* HMW-map protein:antibody complex is being detected. Preferred indicator molecules that are antibodies include, for example, anti-IgE antibodies, anti-IgG antibodies and antibodies that are known bind to *Der* HMW-map protein but bind to a different epitope on *Der* HMW-map protein than antibodies identified in the putative antibody-containing composition. Preferred lectins include those lectins that bind to high-mannose groups. An indicator molecule itself can be attached to a detectable marker of the present invention. For example, an antibody can be conjugated to biotin, horseradish peroxidase, alkaline phosphatase or fluorescein.

In one preferred embodiment, a *Der* HMW-map protein:antibody complex is detected by contacting the complex with an indicator molecule that selectively binds to an IgE antibody (referred to herein as an anti-IgE reagent) or an IgG antibody (referred to herein as an anti-IgG reagent). Examples of such an anti-IgE or an anti-IgG antibody include, but are not limited to, a secondary antibody that is an anti-isotype antibody (e.g., an antibody that selectively binds to the constant region of an IgE or an IgG), an antibody-binding bacterial surface protein (e.g., Protein A or Protein G), an antibody-binding cell (e.g., a B cell, a T cell, a natural killer cell, a polymorphonuclear leukocyte cell, a monocyte cell or a macrophage cell), an antibody-binding eukaryotic cell surface

protein (e.g., a Fc receptor), and an antibody-binding complement protein. Preferred indicator molecules include, but are not limited to, an anti-feline IgE antibody, an anti-feline IgG antibody, an anti-canine IgE antibody, an anti-canine IgG antibody, an anti-human IgE antibody, and an anti-human IgG antibody. As used herein, an anti-IgE or anti-IgG antibody includes not only a complete antibody but also any subunit or portion thereof that is capable of selectively binding to an IgE or IgG heavy chain constant region. For example, an anti-IgE reagent or anti-IgG reagent can include an Fab fragment or a F(ab')₂ fragment, both of which are described in detail in Janeway et al., in *Immunobiology, the Immune System in Health and Disease*, Garland Publishing, Inc., NY, 1996 (which is incorporated herein by this reference in its entirety).

In another preferred embodiment, a *Der* HMW-map protein:antibody complex is detected by contacting the complex with an indicator molecule that selectively binds to *Der* HMW-map protein at a different epitope than the epitope at which an antibody in a putative antibody-containing composition binds to *Der* HMW-map protein.

In one embodiment a complex can be formed and detected in solution. In another embodiment, a complex can be formed in which one or more members of the complex are immobilized on (e.g., coated onto) a substrate. Immobilization techniques are known to those skilled in the art. Suitable substrate materials include, but are not limited to, plastic, glass, gel, celluloid, paper, PVDF (poly-vinylidene-fluoride), nylon, nitrocellulose, and particulate materials such as latex, polystyrene, nylon, nitrocellulose, agarose and magnetic resin. Suitable shapes for substrate material include, but are not limited to, a well (e.g., microtiter dish well), a plate, a dipstick, a bead, a lateral flow apparatus, a membrane, a filter, a tube, a dish, a celluloid-type matrix, a magnetic

particle, and other particulates. A particularly preferred substrate comprises an ELISA plate, a dipstick, a radioimmunoassay plate, agarose beads, plastic beads, latex beads, immunoblot membranes and immunoblot papers. In one embodiment, a substrate, such as a particulate, can include a detectable marker.

5 A preferred method to detect antibody that binds to *Der* HMW-map protein is an immunoabsorbent assay. An immunoabsorbent assay of the present invention comprises a capture molecule and an indicator molecule. A capture molecule of the present invention binds to an IgE or an IgG in such a manner that the IgE or IgG is immobilized to a substrate. As such, a capture molecule is preferably immobilized to a substrate of the present invention prior to exposure of the capture molecule to a putative IgE-containing composition or a putative IgG-containing composition. An indicator molecule of the present invention detects the presence of an IgE or an IgG bound to a capture molecule. As such, an indicator molecule preferably is not immobilized to the same substrate as a capture molecule prior to exposure of the capture molecule to a putative IgE-containing composition or a putative IgG-containing composition.

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A preferred immunoabsorbent assay method includes a step of either:

- (a) immobilizing a *Der* HMW-map protein on a substrate prior to contacting a *Der* HMW-map protein with a putative IgE-containing composition or a putative IgG-containing composition to form a *Der* HMW-map protein -immobilized substrate; and (b)
- 20 binding a putative IgE-containing composition or a putative IgG-containing composition on a substrate prior to contacting *Der* HMW-map protein with a putative IgE-containing composition or a putative IgG-containing composition, to form a putative IgE-containing composition-bound substrate or a putative IgG-containing composition-bound substrate,

respectively. Preferably, the substrate includes a non-coated substrate, a *Der* HMW-map protein -immobilized substrate, an anti-IgE antibody-immobilized substrate or anti-IgG antibody-immobilized substrate.

Both a capture molecule and an indicator molecule of the present invention are capable of binding to an IgE, an IgG or *Der* HMW-map protein. Preferably, a capture molecule binds to a different region of an IgE, an IgG or *Der* HMW-map protein than an indicator molecule, thereby allowing a capture molecule to be bound to an IgE, an IgG or *Der* HMW-map protein at the same time as an indicator molecule. The use of a reagent as a capture molecule or an indicator molecule depends upon whether the molecule is immobilized to a substrate when the molecule is exposed to an IgE, an IgG or *Der* HMW-map protein. For example, a *Der* HMW-map protein of the present invention is used as a capture molecule when the *Der* HMW-map protein is bound on a substrate.

Alternatively, a *Der* HMW-map protein is used as an indicator molecule when the *Der* HMW-map protein is not bound on a substrate. Suitable molecules for use as capture molecules or indicator molecules include, but are not limited to, a *Der* HMW-map protein of the present invention, an anti-IgE antibody reagent or an anti-IgG antibody reagent of the present invention.

An immunoabsorbent assay of the present invention can further comprise one or more layers and/or types of secondary molecules or other binding molecules capable of detecting the presence of an indicator molecule. For example, an untagged (i.e., not conjugated to a detectable marker) secondary antibody that selectively binds to an indicator molecule can be bound to a tagged (i.e., conjugated to a detectable marker) tertiary antibody that selectively binds to the secondary antibody. Suitable secondary

antibodies, tertiary antibodies and other secondary or tertiary molecules can be selected by those of skill in the art. Preferred secondary molecules of the present invention include an antigen, an anti-IgE idiotypic antibody (i.e., an antibody that binds to an epitope unique to the anti-IgE antibody), an anti-IgE isotypic antibody, an anti-IgG idiotypic antibody (i.e., an antibody that binds to an epitope unique to the anti-IgG antibody), and an anti-IgG isotypic antibody. Preferred tertiary molecules can be selected by a skilled artisan based upon the characteristics of the secondary molecule. The same strategy is applied for subsequent layers.

In one embodiment, *Der* HMW-map protein is used as a capture molecule by being immobilized on a substrate, such as a microtiter dish well or a dipstick. A biological sample collected from an animal is applied to the substrate and incubated under conditions suitable (i.e., sufficient) to allow for *Der* HMW-map protein:antibody complex formation bound to the substrate (i.e., IgE or IgG in a sample binds to *Der* HMW-map protein immobilized on a substrate). Excess non-bound material (i.e., material from the biological sample that has not bound to the *Der* HMW-map protein), if any, is removed from the substrate under conditions that retain antigen:antibody complex binding to the substrate. Preferred conditions are generally disclosed in Sambrook et al., *ibid*. An indicator molecule that can selectively bind to an IgE or an IgG bound to the antigen is added to the substrate and incubated to allow formation of a complex between the indicator molecule and the *Der* HMW-map protein:antibody complex. Excess indicator molecule is removed, a developing agent is added if required, and the substrate is submitted to a detection device for analysis. A preferred indicator molecule for this embodiment is an anti-IgG antibody to detect IgG antibody bound to *Der* HMW-map

protein or an anti-IgE antibody to detect IgE antibody bound to *Der* HMW-map protein.

Preferably the anti-IgG or anti-IgE antibody are conjugated to biotin, to a fluorescent label or to an enzyme label.

In one embodiment, an anti-IgE or anti-IgG antibody (e.g., isotype or idiotype specific antibody) is used as a capture molecule by being immobilized on a substrate, such as a microtiter dish well or a dipstick. A biological sample collected from an animal is applied to the substrate and incubated under conditions suitable to allow for anti-IgE antibody:IgE complex or anti-IgG antibody:IgG complex formation, respectively, bound to the substrate. Excess non-bound material, if any, is removed from the substrate under conditions that retain anti-IgE antibody:IgE complex or anti-IgG antibody:IgG complex binding to the substrate. *Der* HMW-map protein is added to the substrate and incubated to allow formation of a complex between the *Der* HMW-map protein and the anti-IgE antibody:IgE complex or anti-IgG antibody:IgG complex. Preferably, the *Der* HMW-map protein is conjugated to a detectable marker (preferably to biotin, an enzyme label or a fluorescent label). Excess *Der* HMW-map protein is removed, a developing agent is added if required, and the substrate is submitted to a detection device for analysis.

In one embodiment, an immunoabsorbent assay of the present invention does not utilize a capture molecule. In this embodiment, a biological sample collected from an animal is applied to a substrate, such as a microtiter dish well or a dipstick, and incubated under conditions suitable to allow for IgE or IgG binding to the substrate. Any IgE or IgG present in the bodily fluid is immobilized on the substrate. Excess non-bound material, if any, is removed from the substrate under conditions that retain IgE or IgG binding to the substrate. *Der* HMW-map protein is added to the substrate and incubated

to allow formation of a complex between the *Der* HMW-map protein and the IgE or IgG. Preferably, the *Der* HMW-map protein is conjugated to a detectable marker (preferably to biotin, an enzyme label or a fluorescent label). Excess *Der* HMW-map protein is removed, a developing agent is added if required, and the substrate is submitted to a detection device for analysis.

Another preferred method to detect IgE or IgG is a lateral flow assay, examples of which are disclosed in U.S. Patent No. 5,424,193, issued June 13, 1995, by Pronovost et al.; U.S. Patent No. 5,415,994, issued May 16, 1995, by Imrich et al; WO 94/29696, published December 22, 1994, by Miller et al.; and WO 94/01775, published January 20, 1994, by Pawlak et al.; each of these patent publications is incorporated by reference herein in its entirety. In one embodiment, a biological sample is placed in a lateral flow apparatus that includes the following components: (a) a support structure defining a flow path; (b) a labeling reagent comprising a bead conjugated to *Der* HMW-map protein, the labeling reagent being impregnated within the support structure in a labeling zone; and (c) a capture reagent comprising an IgE-binding or an IgG-binding composition. The capture reagent is located downstream of the labeling reagent within a capture zone fluidly connected to the labeling zone in such a manner that the labeling reagent can flow from the labeling zone into the capture zone. The support structure comprises a material that does not impede the flow of the beads from the labeling zone to the capture zone.

20 Suitable materials for use as a support structure include ionic (i.e., anionic or cationic) material. Examples of such a material include, but are not limited to, nitrocellulose (NC), PVDF, carboxymethylcellulose (CM). The support structure defines a flow path that is lateral and is divided into zones, namely a labeling zone and a capture zone. The

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apparatus can further comprise a sample receiving zone located along the flow path, more preferably upstream of the labeling reagent. The flow path in the support structure is created by contacting a portion of the support structure downstream of the capture zone, preferably at the end of the flow path, to an absorbent capable of absorbing excess liquid from the labeling and capture zones.

In this embodiment, the biological sample is applied to the sample receiving zone which includes a portion of the support structure. The labeling zone receives the sample from the sample receiving zone which is directed downstream by the flow path. The labeling zone comprises the labeling reagent that binds to IgE or IgG, or both. A preferred labeling reagent is *Der* HMW-map protein conjugated, either directly or through a linker, to a plastic bead substrate, such as to a latex bead. The substrate also includes a detectable marker, preferably a colorimetric marker. Typically, the labeling reagent is impregnated to the support structure by drying or lyophilization. The sample structure also comprises a capture zone downstream of the labeling zone. The capture zone receives labeling reagent from the labeling zone which is directed downstream by the flow path. The capture zone contains the capture reagent, in this case an anti-IgE or anti-IgG antibody, or both, as disclosed above, that immobilizes the IgE and/or IgG complexed to the *Der* HMW-map protein in the capture zone. The capture reagent is preferably fixed to the support structure by drying or lyophilizing. The labeling reagent accumulates in the capture zone and the accumulation is assessed visually or by an optical detection device.

In another embodiment, a lateral flow apparatus used to detect IgE or IgG includes: (a) a support structure defining a flow path; (b) a labeling reagent comprising an

anti-IgE or an anti-IgG antibody, or both, as described above, the labeling reagent impregnated within the support structure in a labeling zone; and (c) a capture reagent comprising *Der* HMW-map protein, the capture reagent being located downstream of the labeling reagent within a capture zone fluidly connected to the labeling zone in such a manner that the labeling reagent can flow from the labeling zone into the capture zone.

5 The apparatus preferably also includes a sample receiving zone located along the flow path, preferably upstream of the labeling reagent. The apparatus preferably also includes an absorbent located at the end of the flow path.

An animal hypersensitive to *Der* HMW-map protein is identified by comparing 10 the level of immunocomplex formation using samples of body fluid with the level of immunocomplex formation using control samples. An immunocomplex refers to a complex comprising an antibody and *Der* HMW-map protein (i.e., *Der* HMW-map protein:antibody complex). As such, immunocomplexes form using positive control samples and do not form using negative control samples. As such, if a body fluid sample 15 results in immunocomplex formation greater than or equal to immunocomplex formation using a positive control sample, then the animal from which the fluid was taken is hypersensitive to the *Der* HMW-map protein bound to the substrate. Conversely, if a body fluid sample results in immunocomplex formation similar to immunocomplex formation using a negative control sample, then the animal from which the fluid was 20 taken is not hypersensitive to the *Der* HMW-map protein bound to the substrate.

It is within the scope of the present invention that two or more different skin tests and/or *in vitro* tests can be used in combination for diagnostic purposes. For example, the immediate hypersensitivity of an animal to *Der* HMW-map protein can be tested using an

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in vitro immunoabsorbent test capable of detecting IgE antibodies specific for *Der* HMW-map protein in the animal's bodily fluid. While most animals that display delayed hypersensitivity to *Der* HMW-map protein also display immediate hypersensitivity to the allergen, a small number of animals that display delayed hypersensitivity to an allergen do not display immediate hypersensitivity to the allergen. In such cases, following negative results from the IgE-specific *in vitro* test, the delayed hypersensitivity of the animal to *Der* HMW-map protein can be tested using an skin test of the present invention.

The present invention also includes kits to detect antibodies that bind specifically to *Der* HMW-map protein based on each of the disclosed detection methods. One embodiment is a kit to detect *Der* HMW-map protein-specific antibodies comprising *Der* HMW-map protein and a means for detecting an IgE and/or an IgG. Suitable means of detection include compounds disclosed herein that bind to either the *Der* HMW-map protein or to an IgE and/or an IgG. A preferred kit of the present invention further comprises a detection means including an antibody capable of selectively binding to an IgE or IgG disclosed herein and/or a compound capable of binding to a detectable marker conjugated to a *Der* HMW-map protein (e.g., avidin, streptavidin and ImmunoPure® NeutrAvidin when the detectable marker is biotin).

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Another preferred kit of the present invention is an allergen kit comprising *Der* HMW-map protein and an allergen commonly detected in the same environment as mite allergen. Suitable and preferred mite-related allergens for use with the present kit include those mite-related allergens disclosed herein.

A preferred kit of the present invention includes those in which *Der* HMW-map protein is immobilized on a substrate. If a kit comprises *Der* HMW-map protein and another allergen, the kit can comprise one or more compositions, each composition comprising one allergen. As such, each allergen can be tested separately. A kit can also 5 contain two or more diagnostic reagents for IgE or IgG, or other compounds as disclosed herein. Particularly preferred are kits used in a lateral flow assay format. It is within the scope of the present invention that a lateral flow assay kit can include one or more lateral flow assay apparatuses. Multiple lateral flow apparatuses can be attached to each other at one end of each apparatus, thereby creating a fan-like structure.

10 Another aspect of the present invention includes treating animals susceptible to or having mite allergy, with a *Der* HMW-map protein formulation of the present invention. According to the present invention, the term treatment can refer to the regulation of a hypersensitive response by an animal to mite allergens. Regulation can include, for example, immunomodulation of cells involved in the animal's hypersensitive response. 15 Immunomodulation can include modulating the activity of molecules typically involved in an immune response (e.g., antibodies, antigens, major histocompatibility molecules (MHC) and molecules co-reactive with MHC molecules). In particular, immunomodulation refers to modulation of antigen:antibody interactions resulting in inflammatory responses, immunosuppression, and immunotolerization of cells involved 20 in a hypersensitive response. Immunosuppression refers to inhibiting an immune response by, for example, killing particular cells involved in the immune response. Immunotolerization refers to inhibiting an immune response by anergizing (i.e.,

diminishing reactivity of a T cell to an antigen) particular cells involved in the immune response.

One embodiment of the present invention is a therapeutic composition that includes desensitizing compounds capable of inhibiting an immune response to *Der* HMW-map protein of the present invention. Such desensitizing compounds include blocking compounds, toleragens and/or suppressor compounds. Blocking compounds comprise compounds capable of modulating antigen:antibody interactions that can result in inflammatory responses, toleragens are compounds capable of immunotolerizing an animal, and suppressor compounds are capable of immunosuppressing an animal. A desensitizing compound of the present invention can be soluble or membrane-bound. Membrane-bound desensitizing compounds can be associated with biomembranes, including cells, liposomes, planar membranes or micelles. A soluble desensitizing compound of the present invention is useful for: (1) inhibiting a Type I hypersensitivity reaction by blocking IgE:antigen mediated de-granulation of mast cells; (2) inhibiting a Type III hypersensitivity reaction by blocking IgG:antigen complex formation leading to complement destruction of cells; and (3) inhibiting a Type IV hypersensitivity reaction by blocking T helper cell stimulation of cytokine secretion by macrophages. A membrane-bound desensitizing compound of the present invention is useful for: (1) inhibiting a Type II hypersensitivity reaction by blocking IgG:antigen complex formation on the surface of cells leading to complement destruction of cells; (2) inhibiting a Type II hypersensitivity reaction by blocking IgG regulated signal transduction in immune cells; and (3) inhibiting a Type IV hypersensitivity reaction by blocking T cytotoxic cell killing of antigen-bearing cells. Examples of desensitizing compounds include, but are not limited to,

muteins, mimetopes and antibodies of the present invention, as well as other inhibitors of the present invention that inhibit binding between a protein of the present invention and IgE.

A desensitizing compound of the present invention can also be covalently linked
5 to a ligand molecule capable of targeting the desensitizing compound to a specific cell involved in a hypersensitive response to *Der* HMW-map protein. Appropriate ligands with which to link a desensitizing compound include, for example, at least a portion of an immunoglobulin molecule, cytokines, lectins, heterologous allergens, CD8 molecules or major histocompatibility molecules (e.g., MHC class I or MHC class II molecules).
10 Preferred portions of immunoglobulin molecules to link to a desensitizing compound include variable regions capable of binding to immune cell specific surface molecules and constant regions capable of binding to Fc receptors on immune cells, in particular IgE constant regions. Preferred CD8 molecules include at least the extracellular functional domains of the α chain of CD8. An immune cell refers to a cell involved in an immune response, in particular, cells having MHC class I or MHC class II molecules. Preferred
15 immune cells include antigen presenting cells, T cells and B cells.

In one embodiment, a therapeutic composition of the present invention includes
20 *Der* HMW-map protein of the present invention, a mimotope or mutein thereof, or a *Der* HMW-map nucleic acid molecule of the present invention. Suitable therapeutic compositions of the present invention for treating mite allergy include *Der* HMW-map protein, a mimotope or mutein thereof, or a *Der* HMW-map nucleic acid molecule of the present invention. Preferred therapeutic compositions include: an isolated mite allergenic protein encoded a nucleic acid molecule that hybridizes under stringent hybridization

conditions with the complement of a nucleic acid molecule that encodes an amino acid sequence selected from the group consisting of SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:18, SEQ ID NO:21, SEQ ID NO:23, SEQ ID NO:24, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:33, SEQ ID NO:35, SEQ ID NO:38, SEQ ID NO:41, and SEQ ID NO:44; a mimetope of the mite allergenic protein; a mutein of the mite allergenic protein; and an isolated nucleic acid molecule selected from the group consisting of: a nucleic acid molecule comprising at least about 150 nucleotides, wherein said nucleic acid molecule comprising at least about 150 nucleotides hybridizes, in a solution comprising 1X SSC and 0% formamide, at a temperature of about 50°C, to a nucleic acid sequence selected from the group consisting of SEQ ID NO:14, SEQ ID NO:16, SEQ ID NO:17, SEQ ID NO:19, SEQ ID NO:20, SEQ ID NO:22, SEQ ID NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45, and a nucleic acid sequence encoding a protein comprising the amino acid sequence SEQ ID NO:33 and a complement thereof; and a nucleic acid molecule comprising a fragment of any of said nucleic acid molecules comprising at least about 150 nucleotides. A preferred *Der* HMW-map mutein comprises at least a portion of *Der* HMW-map protein, in which a suitable number of cysteine residues have been removed or replaced with a non-cysteine residue such that the altered *Der* HMW-map protein is not toxic to an animal (e.g., does not cause anaphylaxis).

In another embodiment, a therapeutic composition of the present invention includes a nucleic acid molecule encoding a *Der* HMW-map protein that can be administered to an animal in a fashion to enable expression of that nucleic acid molecule into a *Der* HMW-map protein in the animal. Nucleic acid molecules can be delivered to an animal in a variety of methods including, but not limited to, (a) administering a naked (i.e., not packaged in a viral coat or cellular membrane) nucleic acid molecule (e.g., as naked DNA or RNA molecules, such as is taught, for example in Wolff et al., 1990, *Science* 247, 1465-1468) or (b) administering a nucleic acid molecule packaged as a recombinant virus or as a recombinant cell (i.e., the nucleic acid molecule is delivered by a viral or cellular vehicle).

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A naked nucleic acid molecule of the present invention includes a nucleic acid molecule of the present invention and preferably includes a recombinant molecule of the present invention that preferably is replication, or otherwise amplification, competent. A naked nucleic acid of the present invention can comprise one or more nucleic acid molecules of the present invention in the form of, for example, a bicistronic recombinant molecule having, for example one or more internal ribosome entry sites. Preferred naked nucleic acid molecules include at least a portion of a viral genome (i.e., a viral vector). Preferred viral vectors include those based on alphaviruses, poxviruses, adenoviruses, herpesviruses, picornaviruses, and retroviruses, with those based on alphaviruses (such as Sindbis or Semliki virus), species-specific herpesviruses and species-specific poxviruses being particularly preferred. Any suitable transcription control sequence can be used, including those disclosed as suitable for protein production. Particularly preferred transcription control sequence include cytomegalovirus intermediate early (preferably in

conjunction with Intron-A), Rous Sarcoma Virus long terminal repeat, and tissue-specific transcription control sequences, as well as transcription control sequences endogenous to viral vectors if viral vectors are used. The incorporation of "strong" poly(A) sequences are also preferred.

5 Naked nucleic acid molecules of the present invention can be administered by a variety of methods. Suitable delivery methods include, for example, intramuscular injection, subcutaneous injection, intradermal injection, intradermal scarification, particle bombardment, oral application, and nasal application, with intramuscular injection, intradermal injection, intradermal scarification and particle bombardment being preferred, and intramuscular injection being even more preferred. A preferred single dose of a naked DNA molecule ranges from about 1 nanogram (ng) to about 1 milligram (mg), depending on the route of administration and/or method of delivery, as can be determined by those skilled in the art. Examples of administration methods are disclosed, for example, in U.S. Patent No. 5,204,253, by Bruner, et al., issued April 20, 1993, PCT Publication No. WO 95/19799, published July 27, 1995, by McCabe, and PCT Publication No. WO 95/05853, published March 2, 1995, by Carson, et al. Naked DNA molecules of the present invention can be contained in an aqueous excipient (e.g., phosphate buffered saline) and/or with a carrier (e.g., lipid-based vehicles), or it can be bound to microparticles (e.g., gold particles).

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A recombinant virus of the present invention includes a recombinant molecule of the present invention that is packaged in a viral coat and that can be expressed in an animal after administration. Preferably, the recombinant molecule is packaging-deficient and/or encodes an attenuated virus. A number of recombinant viruses can be used,

including, but not limited to, those based on alphaviruses, poxviruses, adenoviruses, herpesviruses, picornaviruses and retroviruses. Preferred recombinant viruses are those based on alphaviruses (such as Sindbis virus), raccoon poxviruses, species-specific herpesviruses and species-specific poxviruses. An example of methods to produce and 5 use alphavirus recombinant virus is disclosed in PCT Publication No. WO 94/17813, by Xiong et al., published August 18, 1994, which is incorporated by reference herein in its entirety.

When administered to an animal, a recombinant virus of the present invention infects cells within the recipient animal and directs the production of a protein or RNA 10 nucleic acid molecule that is capable of reducing *Der* HMW-map protein-mediated biological responses in the animal. For example, a recombinant virus comprising a *Der* HMW-map nucleic acid molecule of the present invention is administered according to a protocol that results in the animal producing an amount of protein or RNA sufficient to reduce *Der* HMW-map protein-mediated biological responses. A preferred single dose of 15 a recombinant virus of the present invention is from about 1×10^4 to about 1×10^7 virus plaque forming units (pfu) per kilogram body weight of the animal. Administration protocols are similar to those described herein for protein-based compositions, with subcutaneous, intramuscular, intranasal and oral administration routes being preferred.

A recombinant cell vaccine of the present invention includes recombinant cells of 20 the present invention that express at least one protein of the present invention. Preferred recombinant cells for this embodiment include *Salmonella*, *E. coli*, *Listeria*, *Mycobacterium*, *S. frugiperda*, yeast, (including *Saccharomyces cerevisiae* and *Pichia pastoris*), BHK, CV-1, myoblast G8, COS (e.g., COS-7), Vero, MDCK and CRFK.

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recombinant cells. Recombinant cell vaccines of the present invention can be administered in a variety of ways but have the advantage that they can be administered orally, preferably at doses ranging from about 10^8 to about 10^{12} cells per kilogram body weight. Administration protocols are similar to those described herein for protein-based vaccines. Recombinant cell vaccines can comprise whole cells, cells stripped of cell walls or cell lysates.

The efficacy of a therapeutic composition of the present invention to desensitize an animal against mite allergy can be tested in a variety of ways including, but not limited to, using *in vivo* skin test methods disclosed herein, detection of cellular immunity activity in the treated animal, or determine levels of IgE that bind specifically to a *Der* HMW-map protein of the present invention. Methods to determine cellular immunity activity and IgE levels in an animal are known to those of skill in the art. In one embodiment, therapeutic compositions can be tested in animal models such as dogs, cats, rabbits and mice, and can also be tested in humans. Such techniques are known to those skilled in the art.

Preferred nucleic acid molecules to use with a therapeutic composition of the present invention include any *Der* HMW-map nucleic acid molecule disclosed herein, in particular SEQ ID NO:14, SEQ ID NO:16, SEQ ID NO:17, SEQ ID NO:19, SEQ ID NO:20, SEQ ID NO:22, SEQ ID NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45 and/or a nucleic acid sequence encoding a protein comprising the amino acid sequence SEQ ID NO:33 and a complement thereof.

A recombinant cell useful in a therapeutic composition of the present invention includes recombinant cells of the present invention that comprises *Der* HMW-map protein of the present invention. Preferred recombinant cells for this embodiment include *Salmonella*, *E. coli*, *Listeria*, *Mycobacterium*, *S. frugiperda*, yeast, (including 5 *Saccharomyces cerevisiae*), BHK, CV-1, myoblast G8, COS (e.g., COS-7), Vero, MDCK and CRFK recombinant cells. A recombinant cell of the present invention can be administered in a variety of ways but have the advantage that they can be administered orally, preferably at doses ranging from about 10⁸ to about 10¹² cells per kilogram body weight. Administration protocols are similar to those described herein for protein 10 compositions. Recombinant cells can comprise whole cells, cells stripped of cell walls or cell lysates.

One embodiment of the present invention is a method of immunotherapy comprising administering to an animal an effective amount of a therapeutic composition comprising a *Der* HMW-map protein of the present invention. Suitable therapeutic compositions and methods of administration are disclosed herein. According to the 15 present invention, a therapeutic composition and method of the present invention can be used to prevent or alleviate symptoms associated with mite allergen pathogenesis.

The efficacy of a therapeutic composition of the present invention to effect an allergic response to *Der* HMW-map protein can be tested using standard methods for 20 detecting *Der* HMW-map protein-mediated immunity including, but not limited to, immediate hypersensitivity, delayed hypersensitivity, antibody-dependent cellular cytotoxicity (ADCC), immune complex activity, mitogenic activity, histamine release assays and other methods such as those described in Janeway et al., *ibid.*

The present invention also includes a therapeutic composition comprising one or more therapeutic compounds of the present invention. Examples of such therapeutic compounds include, for example, other allergens disclosed herein.

Therapeutic compositions of the present invention can be formulated in an excipient that the animal to be treated can tolerate. Examples of such excipients include water, saline, Ringer's solution, dextrose solution, Hank's solution, and other aqueous physiologically balanced salt solutions. Nonaqueous vehicles, such as fixed oils, sesame oil, ethyl oleate, or triglycerides may also be used. Other useful formulations include suspensions containing viscosity enhancing agents, such as sodium carboxymethylcellulose, sorbitol, or dextran. Excipients can also contain minor amounts of additives, such as substances that enhance isotonicity and chemical stability. Examples of buffers include phosphate buffer, bicarbonate buffer and Tris buffer, while examples of preservatives include thimerosal, o-cresol, formalin and benzyl alcohol. Standard formulations can either be liquid injectables or solids which can be taken up in a suitable liquid as a suspension or solution for injection. Thus, in a non-liquid formulation, the excipient can comprise dextrose, human serum albumin, preservatives, etc., to which sterile water or saline can be added prior to administration.

In one embodiment of the present invention, a therapeutic composition can include an adjuvant. Adjuvants are agents that are capable of enhancing the immune response of an animal to a specific antigen. Suitable adjuvants include, but are not limited to, cytokines, chemokines, and compounds that induce the production of cytokines and chemokines (e.g., granulocyte macrophage colony stimulating factor (GM-CSF), granulocyte colony stimulating factor (G-CSF), macrophage colony stimulating

factor (M-CSF), colony stimulating factor (CSF), Flt-3 ligand, erythropoietin (EPO), interleukin 2 (IL-2), interleukin-3 (IL-3), interleukin 4 (IL-4), interleukin 5 (IL-5), interleukin 6 (IL-6), interleukin 7 (IL-7), interleukin 8 (IL-8), interleukin 10 (IL-10), interleukin 12 (IL-12), interferon gamma, interferon gamma inducing factor I (IGIF), transforming growth factor beta, RANTES (regulated upon activation, normal T cell expressed and presumably secreted), macrophage inflammatory proteins (e.g., MIP-1 alpha and MIP-1 beta), and Leishmania elongation initiating factor (LEIF); bacterial components (e.g., endotoxins, in particular superantigens, exotoxins and cell wall components); aluminum-based salts; calcium-based salts; silica; polynucleotides; toxoids; serum proteins, viral coat proteins; block copolymer adjuvants (e.g., Hunter's Titermax™ adjuvant (Vaxcel™, Inc. Norcross, GA), Ribi adjuvants (Ribi ImmunoChem Research, Inc., Hamilton, MT); and saponins and their derivatives (e.g., Quil A (Superfos Biosector A/S, Denmark). Protein adjuvants of the present invention can be delivered in the form of the protein themselves or of nucleic acid molecules encoding such proteins using the methods described herein.

In one embodiment of the present invention, a therapeutic composition can include a carrier. Carriers include compounds that increase the half-life of a therapeutic composition in the treated animal. Suitable carriers include, but are not limited to, polymeric controlled release vehicles, biodegradable implants, liposomes, bacteria, viruses, other cells, oils, esters, and glycols.

One embodiment of the present invention is a controlled release formulation that is capable of slowly releasing a composition of the present invention into an animal. As used herein, a controlled release formulation comprises a composition of the present

invention in a controlled release vehicle. Suitable controlled release vehicles include, but
are not limited to, biocompatible polymers, other polymeric matrices, capsules,
microcapsules, microparticles, bolus preparations, osmotic pumps, diffusion devices,
liposomes, lipospheres, and transdermal delivery systems. Other controlled release
5 formulations of the present invention include liquids that, upon administration to an
animal, form a solid or a gel *in situ*. Preferred controlled release formulations are
biodegradable (i.e., bioerodible).

A preferred controlled release formulation of the present invention is capable of
releasing a therapeutic composition of the present invention into the blood of an animal at
10 a constant rate sufficient to attain therapeutic dose levels of the composition to reduce
mite allergy in the animal. As used herein, mite allergy refers to cellular responses that
occur when mite allergens contact an animal. For example, IgE that specifically binds to
mite allergen becomes coupled with Fc epsilon receptor, resulting in Fc epsilon receptor-
mediated biological response including release of biological mediators, such as
15 histamine, prostaglandins and/or proteases, that can trigger clinical symptoms of allergy.
The therapeutic composition is preferably released over a period of time ranging from
about 1 to about 12 months. A preferred controlled release formulation of the present
invention is capable of effecting a treatment preferably for at least about 1 month, more
preferably for at least about 3 months, even more preferably for at least about 6 months,
20 even more preferably for at least about 9 months, and even more preferably for at least
about 12 months.

Therapeutic compositions of the present invention can be sterilized by conventional methods which do not result in protein degradation (e.g., filtration) and/or lyophilized.

A therapeutic composition of the present invention can be administered to any animal susceptible to mite allergy as herein described. Acceptable protocols by which to administer therapeutic compositions of the present invention in an effective manner can vary according to individual dose size, number of doses, frequency of dose administration, and mode of administration. Determination of such protocols can be accomplished by those skilled in the art. An effective dose refers to a dose capable of treating an animal against hypersensitivity to mite allergens. Effective doses can vary depending upon, for example, the therapeutic composition used and the size and type of the recipient animal. Effective doses to immunomodulate an animal against mite allergens include doses administered over time that are capable of alleviating a hypersensitive response by an animal to mite allergens. For example, a first tolerizing dose can comprise an amount of a therapeutic composition of the present invention that causes a minimal hypersensitive response when administered to a hypersensitive animal. A second tolerizing dose can comprise a greater amount of the same therapeutic composition than the first dose. Effective tolerizing doses can comprise increasing concentrations of the therapeutic composition necessary to tolerate an animal such that the animal does not have a hypersensitive response to exposure to mite allergens. An effective dose to desensitize an animal can comprise a concentration of a therapeutic composition of the present invention sufficient to block an animal from having a hypersensitive response to exposure to a mite allergen present in the environment of the

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animal. Effective desensitizing doses can include repeated doses having concentrations of a therapeutic composition that cause a minimal hypersensitive response when administered to a hypersensitive animal.

A suitable single dose is a dose that is capable of treating an animal against hypersensitivity to mite allergens when administered one or more times over a suitable time period. For example, a preferred single dose of a mite allergen, or mimotope therapeutic composition is from about 0.5 ng to about 1 g of the therapeutic composition per kilogram body weight of the animal. Further treatments with the therapeutic composition can be administered from about 1 day to 1 year after the original administration. Further treatments with the therapeutic composition preferably are administered when the animal is no longer protected from hypersensitive responses to mite allergens. Particular administration doses and schedules can be developed by one of skill in the art based upon the parameters discussed above. Modes of administration can include, but are not limited to, subcutaneous, intradermal, intravenous, nasal, oral, transdermal and intramuscular routes.

A therapeutic composition of the present invention can be used in conjunction with other compounds capable of modifying an animal's hypersensitivity to mite allergens. For example, an animal can be treated with compounds capable of modifying the function of a cell involved in a hypersensitive response, compounds that reduce allergic reactions, such as by systemic agents or anti-inflammatory agents (e.g., anti-histamines, anti-steroid reagents, anti-inflammatory reagents and reagents that drive immunoglobulin heavy chain class switching from IgE to IgG). Suitable compounds useful for modifying the function of a cell involved in a hypersensitive response include,

but are not limited to, antihistamines, cromolyn sodium, theophylline, cyclosporin A, adrenalin, cortisone, compounds capable of regulating cellular signal transduction, compounds capable of regulating adenosine 3',5'-cyclic phosphate (cAMP) activity, and compounds that block IgE activity, such as peptides from IgE or IgE specific Fc receptors, antibodies specific for peptides from IgE or IgE-specific Fc receptors, or antibodies capable of blocking binding of IgE to Fc receptors.

Compositions of the present invention can be administered to any animal having or susceptible to mite allergen hypersensitivity. Preferred animals to treat include mammals and birds, with felines, canines, equines, humans and other pets, work and/or economic food animals. Particularly preferred animals to protect are felines and canines.

Another aspect of the present invention includes a method for prescribing treatment for animals susceptible to or having hypersensitivity to mite allergens, using a formulation of the present invention. A preferred method for prescribing treatment for mite allergen hypersensitivity, for example, comprises: (1) intradermally injecting into an animal at one site an effective amount of a formulation containing a mite allergen of the present invention, or a mimotope thereof (suitable and preferred formulations are disclosed herein); (2) intradermally injecting into the animal at a second site an effective amount of a control solution; (3) evaluating if the animal has mite allergen hypersensitivity by measuring and comparing the wheal size resulting from injection of the formulation with the wheal size resulting from injection of the control solution; and (4) prescribing a treatment for the mite allergen hypersensitivity.

An alternative preferred method for prescribing treatment for mite allergen hypersensitivity comprises: (1) contacting a first portion of a sample of bodily fluid

obtained from an animal to be tested with an effective amount of a formulation containing mite allergen, or a mimotope thereof (suitable and preferred formulations are disclosed herein) to form a first immunocomplex solution; (2) contacting a positive control antibody to form a second immunocomplex solution; (3) evaluating if the animal has mite allergen hypersensitivity by measuring and comparing the amount of immunocomplex formation in the first and second immunocomplex solutions; and (4) prescribing a treatment for the mite allergen hypersensitivity. It is to be noted that similar methods can be used to prescribe treatment for allergies using mite allergen formulations as disclosed herein.

Another aspect of the present invention includes a method for monitoring animals susceptible to or having mite allergen hypersensitivity, using a formulation of the present invention. *In vivo* and *in vitro* tests of the present invention can be used to test animals for mite allergen hypersensitivity prior to and following any treatment for mite allergen hypersensitivity. A preferred method to monitor treatment of mite allergen hypersensitivity (which can also be adapted to monitor treatment of other allergies) comprises: (1) intradermally injecting an animal at one site with an effective amount of a formulation containing mite allergen, or a mimotope thereof (suitable and preferred formulations are disclosed herein); (2) intradermally injecting an effective amount of a control solution into the animal at a second site; and (3) determining if the animal is desensitized to mite allergens by measuring and comparing the wheal size resulting from injection of the formulation with the wheal size resulting from injection of the control solution.

An alternative preferred method to monitor treatment of mite allergen hypersensitivity (which can be adapted to monitor treatments of other allergies) comprises: (1) contacting a first portion of a sample of bodily fluid obtained from an animal to be tested with an effective amount of a formulation containing a mite allergen or mimotope thereof (suitable and preferred formulations are disclosed herein) to form a first immunocomplex solution; (2) contacting a positive control antibody to form a second immunocomplex solution; and (3) determining if the animal is desensitized to mite allergens by measuring and comparing the amount of immunocomplex formation in the first and second immunocomplex solutions.

The present invention also includes antibodies capable of selectively binding to mite allergen, or mimotope thereof. Such an antibody is herein referred to as an anti-mite allergen antibody. As used herein, the term "selectively binds to" refers to the ability of such an antibody to preferentially bind to mite allergens and mimotopes thereof. In particular, the present invention includes antibodies capable of selectively binding to *Der* HMW-map protein. Binding can be measured using a variety of methods known to those skilled in the art including immunoblot assays, immunoprecipitation assays, enzyme immunoassays (e.g., ELISA), radioimmunoassays, immunofluorescent antibody assays and immunoelectron microscopy; see, for example, Sambrook et al., *ibid.*

Antibodies of the present invention can be either polyclonal or monoclonal antibodies. Antibodies of the present invention include functional equivalents such as antibody fragments and genetically-engineered antibodies, including single chain antibodies, that are capable of selectively binding to at least one of the epitopes of the protein or mimotope used to obtain the antibodies. Preferred antibodies are raised in

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response to *Der* HMW-map proteins, or mimetopes thereof. More preferred *Der* HMW-map protein against which to raise an antibody includes at least a portion of a protein having the amino acid sequence SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:18, SEQ ID NO:21, SEQ ID NO:23, SEQ ID NO:24, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:33, SEQ ID NO:35, SEQ ID NO:38, SEQ ID NO:41, and/or SEQ ID NO:44, or homologs thereof. Preferably, an antibody of the present invention has a single site binding affinity of from about $10^3 M^{-1}$ to about $10^{12} M^{-1}$ for a *Der* HMW-map protein of the present invention.

A preferred method to produce antibodies of the present invention includes administering to an animal an effective amount of a *Der* HMW-map protein or mimotope thereof to produce the antibody and recovering the antibodies. Antibodies raised against defined products or mimetopes can be advantageous because such antibodies are not substantially contaminated with antibodies against other substances that might otherwise cause interference in a diagnostic assay or side effects if used in a therapeutic composition.

Antibodies of the present invention have a variety of potential uses that are within the scope of the present invention. For example, such antibodies can be used (a) as vaccines to passively immunize an animal in order to protect the animal from mite allergen hypersensitivity, (b) as positive controls in test kits, and/or (c) as tools to recover desired mite allergens from a mixture of proteins and other contaminants.

The following examples are provided for the purposes of illustration and are not intended to limit the scope of the present invention.

EXAMPLES

It is to be noted that the Examples include a number of molecular biology,
5 microbiology, immunology and biochemistry techniques considered to be known to those skilled in the art. Disclosure of such techniques can be found, for example, in Sambrook et al., *ibid.*, and related references.

Example 1

This example describes the identification of high molecular weight proteins that bind to IgE from dogs known to be allergic to mite allergens.
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About 5.5 grams (g) of frozen wet *Dermataphagoides fariniae* (*Der f*) mites (available from Bayer Allergy, Spokane, WA) were homogenized in a ground glass homogenizer, in either about 30 ml of phosphate buffered saline (PBS) or 0.1 M Tris-HCl, pH 8, each containing complete protease inhibitors (available from Boehringer Mannheim, Indianapolis, IN) to obtain a *Der f* crude extract. The resulting supernatants were collected and each concentrated in a Centriprep 30 concentrator (available from Amicon, Beverly, MA) by centrifugation at 16,000 x g for about 30 minutes. The concentrated supernatants were applied to separate Sephadryl S-100 columns (2.7 x 70 cm; available from Pharmacia, Piscataway, NJ) in PBS or 0.1 M Tris-HCl, pH 8, respectively. The excluded fractions from each column were pooled. Fractions were dialyzed against 10 mM Tris-HCl, pH 8, when PBS was used. The fractions were applied to separate Q-Sepharose columns (2.5 x 5 cm; available from Pharmacia). The Q-Sepharose column was pre-equilibrated in 10 mM Tris-HCl, pH 8, when the fractions
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containing 0.1 M Tris-HCl, pH 8 were used. Each column was sequentially eluted with about 45 ml of 10 mM Tris-HCl, pH 8, then 0.1 M Tris-HCl, pH 8, then 0.2 M Tris-HCl, pH 8, then 0.3 M Tris-HCl, pH 8, then 0.4 M Tris-HCl, pH 8 and then 0.5 M Tris-HCl, pH 8. Fractions were collected from each elution step. Each fraction was analyzed by western blot for the presence of protein that bound to IgE antibodies present in dog sera isolated from dogs known to be allergic to mite allergens (referred to herein as mite allergic dog antisera or mite allergic antisera). Specifically, proteins contained in the fractions were resolved by 12% Tris-glycine SDS-PAGE and then blotted onto nitrocellulose. The blot was incubated with a pool of sera obtained from dogs known to be allergic to mite allergens, diluted 1:20, using standard buffers. The blot was incubated and then washed using standard procedures. The blot was then incubated with the mouse monoclonal anti-dog IgE antibody DEI38 (1 mg/ml, 1:1000 dilution). The blot was incubated and then washed using standard procedures. The blot was then incubated with donkey anti-mouse IgG antibody conjugated to horseradish peroxidase (1:1000 dilution; available from Jackson Labs, Maine). The presence of HRP-conjugated antibody bound to the blot was detected using standard techniques. An about 70-kD protein was identified in the 0.2 M Tris-HCl, pH 8 fraction, an about 98-kD protein and an about 109-kD protein were identified in the 0.3 M Tris-HCl, pH 8 fraction.

The fraction described above that was eluted using 0.3 M Tris-HCl, pH 8 was concentrated in a Centriprep 30 concentrator and then diluted in 20 mM Na-Ac, pH 5.6. The diluted fraction was then applied to a PolyCat A HPLC cation exchange column (available from PolyLC, Columbia, MD). The column was eluted with about 10 ml of 20 mM Na-Ac, pH 5.6, and then with about 45 ml of a linear gradient from 0 to 0.5 M NaCl

in the 20 mM Na-Ac, pH 5.6 buffer at a flow rate of about 1ml/min. Fractions were collected from the elution procedure and assayed for the presence of high molecular weight proteins using the mite allergic antisera and western blot protocol described above. Fractions containing the high molecular weight proteins were pooled.

5 Trifluoroacetic acid (TFA) was added to a concentration of about 0.05%. The solution was applied to a TSK-Gel TMS-250 C1 reverse phase column (available from TosoHaas, Montgomeryville, PA) that had been pre-equilibrated in 80% solvent A and 20% solvent B. Solvent A was composed of about 0.05% TFA in water and solvent B was composed of about 0.05% TFA in 90% acetonitrile in water. The column was eluted with about 5 ml of 20% solvent B and then with 36 ml of a linear gradient of about 20% to about 70% solvent B at 0.6 ml/min. The proteins eluted from the column were resolved by 12% Tris-Glycine PAGE. The gel was stained with Comassie blue. The stained gel is shown in Fig. 1. Lane 1 contains Mark-12 protein molecular weight markers (available from Novex, San Diego, CA), lane 2 contains the protein eluted from the reverse phase column, and lane 3 contains SeeBlue™ protein molecular weight markers (available from Novex). Two major proteins were identified in the eluant. The molecular weights of the proteins were determined using a BioRad™ Multi-Analyst™/PC Image System (available from BioRad Corp.). The higher molecular weight protein in lane 2 of Fig. 1 was determined to be about 109 kD, referred to herein as mite allergen protein A (mapA).

10 15 20 The lower molecular weight protein in lane 2 of Fig. 1 was determined to be about 98 kD, referred to herein as mite allergen protein B (mapB). The purity of the combined proteins was greater than 85% purity, i.e., less than 15% impurities. This purified eluant is referred to herein as the *D. farinae* high molecular weight map (HMW-map) composition.

Example 2

This example describes N-terminal sequencing of proteins in the *D. farinae* HMW-map composition.

Proteins contained in the 0.3 M Tris-HCl, pH 8 fraction obtained as described above in Example 1 were resolved by SDS-PAGE using a 12% Tris-glycine polyacrylamide-SDS gel, followed by coomasie staining. The proteins were blotted onto PVDF, stained with Coomasie R-250 and destained using standard procedures. The proteins corresponding to the about 98 kD and about 109 kD bands were excised and subjected separately to N-terminal amino acid sequencing using techniques known to those skilled in the art. A partial N-terminal amino acid sequence of about 14 amino acids was deduced for both proteins and the sequences were determined to be identical. The N-terminal amino acid sequence is represented herein as SEQ ID NO:1, having the amino acid sequence: Ser Ile Lys Arg Asp His Asn Asp Tyr Ser Lys Asn Pro Met.

The proteins in the *D. farinae* HMW-map composition were also submitted to proteolytic cleavage in order to obtain internal amino acid sequence data. Specifically, the *D. farinae* HMW-map composition was cleaved with Endoproteinase Asp-N (available from Boehringer Mannheim Biochemica, Indianapolis, IN) using methods standard in the art. The digested protein was then resolved by HPLC using the method described by Stone et al., Enzymatic Digestion of Proteins and HPLC Peptide Isolation, in A Practical Guide to Protein and Peptide Purification for Microsequencing, PT Matsudaira ed., Academic Press, San Diego, CA. Twelve proteolytic fragments were isolated, that are referred to herein as map(1), map(2), map(3), map(4), map(5), map(6), map(7), map(8), map(9), map(10), map(11) and map(12).

The N-terminal partial amino acid sequence of map(1) was determined to be Asp Tyr Glu Tyr Pro Gly Ser Arg Leu Gly Asn Pro Lys Ala Pro Leu Tyr Lys Arg Pro, also denoted SEQ ID NO:2. The N-terminal partial amino acid sequence of map(2) was determined to be Asp Ile Pro His Pro Thr Asn Ile His Lys Tyr Leu Val Cys Glu Ser Val Asn Gly Gly, also denoted SEQ ID NO:3. The N-terminal partial amino acid sequence of map(3) was determined to be Asp Pro Ala Lys Gly Met Ser Pro Pro Gly Phe Ile Val Gly Glu Glu Gly Val Leu Ser, also denoted SEQ ID NO:4. The N-terminal partial amino acid sequence of map(4) was determined to be Asp Glu Lys Asn Ser Phe Glu Cys Ile Leu Gly Pro, also denoted SEQ ID NO:5. The N-terminal partial amino acid sequence of map(5) was determined to be Asp Ala Phe Glu Pro His Gly Tyr Leu Leu Thr Ala Ala Val Ser Pro Gly Lys, also denoted SEQ ID NO:6. The N-terminal partial amino acid sequence of map(6) was determined to be Asp Lys Gln Asn Tyr Leu Ala Leu Val Arg Glu Leu Lys, also denoted SEQ ID NO:7. The N-terminal partial amino acid sequence of map(7) was determined to be Asp Met Ala Gln Asn Tyr Lys Tyr Arg Gln Gln Phe Ile Gln Ser Val Leu Asn Asn Gly Ala Thr Arg Gln, also denoted SEQ ID NO:8. The N-terminal partial amino acid sequence of map(8) was determined to be Asp Glu Xaa Asn Val Met Xaa Tyr Val Leu Tyr Thr Met His Tyr Tyr Leu Asn Asn Gly Ala Thr Arg, also denoted SEQ ID NO:9, in which Xaa represents any amino acid. The N-terminal partial amino acid sequence of map(9) was determined to be Asp Lys Leu Val Met Gly Val Pro Phe Tyr Gly Arg Ala Xaa Ser Ile Glu, also denoted SEQ ID NO:10, in which Xaa represents any amino acid. The N-terminal partial amino acid sequence of map(10) was determined to be Asp Ile Pro His Pro Thr Asn Ile His Lys Tyr Leu Val Cys Glu Ser Val Asn Gly, also denoted SEQ ID NO:11. The N-terminal partial amino acid sequence of map(11) was

determined to be Asp Tyr Ala Lys Asn Pro Lys Arg Ile Val Cys Ile Val Gly Thr Glu Gly
Val Leu Ser, also denoted SEQ ID NO:12. The N-terminal partial amino acid sequence
of map(12) was determined to be Asp Pro Ala Lys Gly Met Ser Pro Pro Gly He Ile Val
Gly Glu Glu Gly Val Leu Ser, also denoted SEQ ID NO:13. Since the amino acid
5 sequences for map(1), map(2), map(3), map(4), map(5), map(6), map(7), map(8), map(9),
map(10), map(11), map(12), and map(13) were generated from a mixture of mapA and
mapB proteins, these sequences do not necessarily represent partial sequences of a single
protein.

Example 3

10 This example describes the purification of a 70-kD protein that binds to IgE from
dogs known to be allergic to mite allergens.

The fraction described above in Example 1 that was eluted using 0.2 M Tris-HCl,
pH 8 was concentrated in a Centriprep 30 concentrator and then diluted in 20 mM Na-Ac,
pH 5.6. The diluted protein was then applied to a PolyCat A HPLC cation exchange
15 column. The column was eluted with about 10 ml of 20 mM Na-Ac, pH 5.6, and then
with about 45 ml of a linear gradient from 0 to 0.5 M NaCl in the 20 mM Na-Ac, pH 5.6
buffer at a flow rate of about 1 ml/min. Fractions were collected from the elution
procedure and assayed for the presence of 70-kD protein using the mite allergic antisera
and western blot protocol described above. Fractions containing the 70-kD protein were
20 pooled. Trifluoroacetic acid (TFA) was added to a concentration of about 0.05%. The
solution was applied to a TSK-Gel TMS-250 C1 reverse phase column that had been
pre-equilibrated in 80% solvent A and 20% solvent B. Solvent A was composed of about
0.05% TFA in water and solvent B was composed of about 0.05% TFA in 90%

acetonitrile in water. The column was eluted with about 3 ml of 20% solvent B and then with 36 ml of a linear gradient of about 20% to about 70% solvent B at 0.6 ml/min. An about 70-kD protein of >90% purity was obtained. The about 70-kD protein is referred to herein as mapC.

5 N-terminal sequence of a region on an SDS-PAGE corresponding to the 70 kD protein (mapC) was obtained as described in Example 2. An N-terminal amino acid sequence of about 21 amino acids was deduced with an 80% confidence level, and is represented herein as SEQ ID NO:33, having the following amino acid sequence: Gln Ser Arg Asp Arg Asn Asp Lys Pro Tyr Xaa Ile Val Lys Lys Lys Lys Ala Leu Asp.

10 Example 4

This example describes the binding of the *D. farinae* HMW-map composition (i.e., containing mapA and mapB) to canine IgE in dog sera isolated from dogs known to be allergic to mite allergens.

15 Multiple wells of an Immulon II microtiter plate were coated with about 100 nanograms per well (ng/well) of a *D. farinae* HMW-map composition isolated according to the method described above in Example 1, diluted in CBC buffer. The plate was
20 incubated overnight at 4°C. Following incubation, the *D. farinae* HMW-map composition-containing solution was removed from the plate, and the plate was blotted dry. The plate was then blocked using about 200 µl/well of 4.0% fetal calf serum contained in phosphate buffered saline (PBS) having 0.05% Tween-20 (PBSTFCS) for about 1 hour at room temperature. The plate was then washed four times with 0.05% Tween-20 in PBS (PBST) using an automatic washer (available from Dynatech, Chantilly, VA). About 100 µl/well of a 1:10 dilution in PBSTFCS of serum samples

isolated from different dogs known to be sensitive to mite allergens in intradermal skin tests were added to the plate. A negative control group of sera was also added to the plate comprising a combination of sera from six dogs that were raised in a barrier facility (available from Harlan Bioproducts, Indianapolis, IN). Some wells did not receive dog sera so that background binding levels could be determined. The plate was incubated for about 1 hour at room temperature and then washed four times with PBST. About 100 μ l/well of a 1:4000 dilution of 40 μ g/ml biotinylated human Fc ϵ R alpha chain protein (produced as described in Frank et al., WO 98/23964, published November 24, 1997) contained in PBSTFCS was added. The plate was incubated for about 1 hour at room temperature and then washed four times with PBST. About 100 μ l of about 0.25 μ g/ml streptavidin conjugated to horseradish peroxidase (available from Kirkegaard and Perry Laboratories (KPL), Gaithersburg, MD; diluted in PBST) was added to each well that received experimental or control samples. The plates were then incubated for about 1 hour at room temperature and washed four times with PBST. About 100 μ l of TMB substrate (available from KPL), that had been pre-warmed to room temperature, was added to each well. The plate was then incubated for about 10 minutes at room temperature and then about 100 μ l/well of Stop Solution (available from KPL) was added. Optical densities (O.D.) of wells were read on a Spectramax Microtiter Plate (available from Molecular Devices Inc.) reader at 450 nm within 10 minutes of adding the stop solution.

The O.D. readings obtained using the negative control sample and the background wells were 0 O.D. Sera from 5 of 26 mite allergen sensitive dogs generated O.D. readings between about 2,000 O.D. and about 3,200 O.D. Sera from 3 other mite allergen

sensitive dogs generated O.D. readings between about 1,000 O.D. and 2,000 O.D. Sera from 3 other mite allergen sensitive dogs generated O.D. readings between about 500 O.D. and 1,000 O.D. Sera from 7 other mite allergen sensitive dogs generated O.D. readings between about 200 O.D. and 500 O.D. Sera from 6 other mite allergen sensitive dogs generated O.D. readings less than 50 O.D. Thus, the results indicate that sera from dogs known to be sensitive to mite allergens contain IgE antibodies that bind specifically to the mapA and mapB proteins of the present invention.

Example 5

This example describes the binding of the 70-kD *D. farinae* protein to canine IgE in dog sera isolated from dogs known to be allergic to mite allergens.

Multiple wells of an Immulon II microtiter plate were coated with about 100 ng/well of 70-kD *D. farinae* protein (referred to herein as mapC) isolated according to the method described above in Examples 1 and 3, diluted in CBC buffer. The plate was incubated overnight at 4°C. The plate was blocked and washed using the method described in Example 4. About 100 µl/well of a 1:10 dilution in PBSTFCS of serum samples isolated from different dogs known to be sensitive to mite allergens in intradermal skin tests were added to the plate. Negative control samples were also added to the plate comprising SPF serum samples (serum from dogs maintained in a barrier facility and therefore never exposed to mite allergens). Some wells did not receive dog sera so that background binding levels could be determined. The plate was incubated for about 1 hour at room temperature and then washed four times with PBST. Biotinylated human FcεR alpha chain protein was then added and the presence of IgE bound to the plate was detected using the methods described in Example 4.

The O.D. readings obtained using the negative control sample and the background wells were 0 O.D. Sera from 3 of 26 mite allergen sensitive dogs generated O.D. readings between about 1,500 O.D. and about 2,700 O.D. Sera from 5 other mite allergen sensitive dogs generated O.D. readings between about 800 and about 1,500 O.D. Sera from 5 other mite allergen sensitive dogs generated O.D. readings between about 500 O.D. and about 800 O.D. Sera from 6 other mite allergen sensitive dogs generated O.D. readings between about 200 O.D. and 500 O.D. Sera from 8 other mite allergen sensitive dogs generated O.D. readings less than 50 O.D. Thus, the results indicate that sera from dogs known to be sensitive to mite allergens contain IgE antibodies that bind specifically to the mapC protein of the present invention.

Example 6

This example describes the binding of mapA, mapB or mapC proteins to feline IgE in cat sera isolated from cats shown by *in vitro* testing to be hypersensitive to mite allergens.

Multiple wells of an Immulon II microtiter plate were coated with about 100 ng/well of a *D. farinae* HMW-map composition (isolated according to the method described above in Example 1) and 70-kD *D. farinae* protein (isolated according to the method described above in Example 3). Other wells of the plate were coated with 400 ng/well of whole *Dermatophagoides pteronyssinus* extract (available from Greer Laboratories, Inc., Lenoir, NC; concentrated 8-fold prior to use) or whole *D. farinae* extract (available from Miles, Inc., Elkhart, IN). All samples were diluted in CBC buffer. The plates were incubated overnight at 4°C. The plates were blocked and washed using the method described in Example 4. About 100 µl/well of a 1:10 dilution in PBSTFCS

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of serum samples isolated from different cats known to be sensitive to mite allergens in *in vitro* allergen testing were added to the plate. Sera from seven control cats (#15, #16, #17, #18, #19, #20, and #21), shown not to be sensitive by *in vitro* test to dust mite allergens, were also tested. Some wells did not receive cat sera so that background binding levels could be determined. The plate was incubated for about 1 hour at room temperature and then washed four times with PBST. Biotinylated human Fc ϵ R alpha chain protein was then added and the presence of IgE bound to the plate was detected using the methods described in Example 4.

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The results are shown below in Table 1. All values represent O.D. values times 1,000. HDM refers to cats that are sensitive to house dust mite allergens (by serological test, i.e. an ELISA to whole *D. farinae* extract).

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Table 1.

Cat #	HDM	Whole <i>Der p</i>	Whole <i>Der f</i>	mapA and mapB	mapC
5	1	+	54	173	211
	2	+	437	454	245
	3	+	96	88	17
	4	+	35	179	278
	5	+	123	23	0
	6	+	2	10	0
10	7	+	84	321	439
	8	+	125	333	611
	9	+	2459	2737	1613
	10	+	17	0	0
	11	+	146	347	243
	12	+	31	100	102
15	13	+	56	171	267
	14	+	121	146	163
	15	-	0	0	0
	16	-	0	0	0
	17	-	0	0	0
	18	-	0	0	0
20	19	-	0	0	0
	20	-	0	0	0
	21	-	23	0	0

The results indicate that sera from some of the cats known to be sensitive to mite allergens contain IgE antibodies that bound specifically to the mapA, mapB or mapC proteins of the present invention. In addition, some sera containing IgE that bound to the mapA, mapB or mapC proteins also contain IgE antibodies that bound to whole *D. pteronyssinus* extract. The control sera did not contain IgE antibodies that bound to either the mapA, mapB or mapC proteins of the present invention.

30 Example 7

This example demonstrates the ability of the *D. farinae* HMW-map composition to induce a hypersensitive response in dogs.

To determine whether the *D. farinae* HMW-map composition described in Example 1 was capable of inducing an allergic response in animals susceptible to dust mite allergic responses, skin tests were performed on dogs that actively demonstrate clinical signs for dust mite allergy (referred to herein as atopic dogs). Normal dogs include dogs that do not show symptoms of mite allergy but may be susceptible to a mite allergic response. Each dog (i.e., 4 normal and 4 atopic dogs) was shaved in the lateral thorax/abdominal area and intradermally injected in different sites in that area with an about 1:50,000 dilution of *D. farinae* crude extract isolated by the method described in Example 1, with about 2 μ g of the purified *D. farinae* HMW-map composition and/or with control solutions, i.e., saline, as a negative control, and a 1:1000 dilution of histamine as a positive control. All four normal dogs and all 4 atopic dogs received *D. farinae* whole extract. Three of the normal dogs and 2 of the atopic dogs received the *D. farinae* HMW-map composition. All 8 of the dogs received both the negative and positive control samples. The total volume per injection was 50 microliters (μ l), with the compositions and controls being diluted in saline. The injections were administered as single injections.

All injection sites were objectively measured in millimeters (mm) at 15 minutes and scored either (+) or (-) when compared with the control samples. The subjective scoring was performed by Andrew Hillier, D.V.M., at Ohio State University, Columbus, OH. The results are shown in Table 2:

Table 2.

	Normal Dog 1	Normal Dog 2	Normal Dog 3	Normal Dog 4	Atopic Dog 1	Atopic Dog 2	Atopic Dog 3	Atopic Dog 4
Whole Extract	+	+	+	-	+	+	-	-
HMW map	+	+	-	n/a	+	-	n/a	n/a
Neg. Control	-	-	-	-	-	-	-	-
Histamine	+	+	+	+	+	+	+	+

n/a = not applicable

The results indicate that the *D. farinae* HMW-map composition was capable of inducing an immediate hypersensitive response in dogs including atopic dogs. Thus, the HMW-map composition is sufficiently allergenic to induce a hypersensitive response in dogs including atopic dogs.

Table 3 describes the results of the following experiment. IgE to the HMW-map composition was measured in the serum of three groups of dogs: *D. farinae* allergic (HDM-AD), atopic (to other allergens) but not HDM allergic (AD), and naive dogs using ELISA. These dogs were also tested by intradermal skin test to *D. farinae* whole extract and to the HMW-map composition.

Table 3. Skin test and ELISA data for *D. farinae* whole extract and for HMW-map composition in *D. farinae*-allergic, atopic but not HDM-allergic, and naive dogs.

Dog	Clinical status	Df IDST 1:50,000	Df ELISA	HMW-map IDST 1ug	HMW-map ELISA
5	1	HDM-AD	+	1968	2876
	2	HDM-AD	+	407	954
	3	HDM-AD	+	3921	3465
	4	HDM-AD	+	153	198
10	5	HDM-AD	+	1712	997
	6	HDM-AD	+	1833	2006
	7	HDM-AD	+	4200	4200
	8	HDM-AD	+	2851	3559
15	9	HDM-AD	+	122	209
	10	HDM-AD	+	1627	566
	11	HDM-AD	+	1185	1307
	12	HDM-AD	+	308	101
20	13	HDM-AD	+	341	433
	14	AD	-	1	0
	15	AD	-	8	2
	16	AD	ND	66	87
25	17	Normal	-	24	40
	18	Normal	-	53	369
	19	Normal	-	37	21
	20	SPF beagle	ND	0	ND
	21	SPF beagle	ND	6	1

All dogs that were positive by ELISA for whole *D. farinae* extract were also positive for the HMW-map composition allergen. Of the eight dogs that were ELISA negative for whole *D. farinae* extract, 7 of 8 were also negative for the HMW-map composition.

Example 8

This example describes the isolation of nucleic acid molecules encoding a *Der* HMW-map composition of the present invention.

Der HMW-map composition nucleic acid molecules were identified and isolated as follows.

A. Preparation of a *Dermatophagoides farinae* cDNA Library.

A *Dermatophagoides farinae* cDNA library was prepared as follows. Total RNA was extracted from about 2 grams of flash frozen and pulverized house dust mites, using an acid-guanidinium-phenol-chloroform method similar to that described by Chomzynski et al., 1987, *Anal. Biochem.* 162, 156-159. Poly A⁺ selected RNA was separated from the total RNA preparation by oligo-dT cellulose chromatography using the mRNA Purification Kit (available from Pharmacia Biotech, Newark, NJ), according to the method recommended by the manufacturer. A cDNA library was constructed in lambda-Uni-ZAPTM XR vector (available from Stratagene), using Stratagene's ZAP-cDNA Synthesis Kit protocol. Approximately 5 µg of Poly A⁺ RNA was used to produce the *Dermatophagoides farinae* cDNA library.

B. Preparation of PCR primers.

Further N-terminal amino acid sequence analysis was performed according to the methods described above in Example 2. A partial N-terminal amino acid sequence of 34 amino acids was deduced and is represented by SEQ ID NO:24, having the amino acid sequence: Ser Ile Lys Arg Asp His Asn Asp Tyr Ser Lys Asn Pro Met Met Ile Val Xaa Tyr Tyr Gly Gly Ser Ser Gly Tyr Gln Ser Xaa Lys Arg Xaa Xaa Thr (wherein "Xaa" represents any amino acid residue). The amino acid sequences of SEQ ID NO:4 (described above in Example 2) and SEQ ID NO:24 were used to design synthetic oligonucleotide primers. Sense primer Derf1 derived from SEQ ID NO:24, having the nucleotide sequence 5' AAA CGT GAT CAT AAY GAT TAY TCN AAR AAY C 3' (wherein Y represents C or T, R represents A or G, and N represents A, C, T or G), designated SEQ ID NO: 25 or sense primer Derf2, derived from SEQ ID NO:24, having

the nucleotide sequence 5' AAA CGT GAT CAT AAY GAT TAY AGY AAR AAY C 3', designated SEQ ID NO:26, were used in combination with antisense primer Derf3 derived from SEQ ID NO:4, having the nucleotide sequence 5' CCT TCT TCA CCN ACR ATC AAN CC 3', denoted SEQ ID NO:27, or antisense primer Derf4 derived from SEQ ID NO:4, having the nucleotide sequence 5' CCT TCT TCA CCN ACR ATG AAN CC 3', denoted SEQ ID NO:28.

The foregoing primers were then used to screen the *Der f* cDNA library using standard polymerase chain reaction amplification (PCR) techniques. All attempts to identify a cDNA that hybridized to the primers failed.

C. Immunoscreening the *D. farinae* cDNA library using anti-*Der* HMW-mapcomposition antibodies.

Since attempts to isolate a cDNA clone using PCR methods failed, the inventors screened the *D. farinae* cDNA library using an antiserum produced as follows. Protein isolated according to the method described above in Example 1 was used as a source of antigen to generate rabbit polyclonal antibodies, referred to herein as anti-*Der* HMW-map composition antibodies. The preparation of rabbit polyclonal antibodies was carried out using standard techniques.

About 7.5 ml of *Escherichia coli* (XL1 Blue, O.D.₆₀₀=0.5) was incubated with 3.0 x 10⁴ pfu of phage from a *Dermatophagoides farinae* ZAP-cDNA library (1.8 x 10⁹ pfu/ml), at 37°C for 15 min and plated in 30 ml Luria-Bertani (LB) medium agar plates (150 mm). The plates were incubated at 37°C over night. Each plate was then overlaid with an IPTG (10 mM) treated nitrocellulose filter for about 4 hours at 37°C. The filters were then removed and washed with Tris buffered saline (pH 7.5) containing 0.1%

Tween (TBST), for 5 minutes. The filters were blocked with a solution of 1% dried powder milk, 1% BSA, 2% goat serum and 0.15% gelatin, prepared in TBST, for 2 hours at room temperature. Filters were then incubated with the anti-*Der* HMW-map composition antibodies at a dilution of 1:1000, contained in the above blocking solution at 4°C, overnight. The mixture was then incubated with a donkey anti-rabbit IgG antibody conjugated to horseradish peroxidase (available from Jackson ImmunoResearch, West Grove, PN) for 2 hours at room temperature. All of the filters were washed with blocking solution contained in TBST (3 x 15 min/wash) between each incubation. All of the filters were then treated to a final wash in Tris buffered saline (pH 7.5) for 5 minutes at room temperature. Immunocomplexed plaques were identified by immersing the filters into the developing solution (TMB Peroxidase Substrate/TMB Peroxidase Solution/TMB Membrane Enhancer from Kirkegaard & Perry Laboratories) at 1/1/0.1 volume ratio to produce a color reaction. One hundred and twenty three plaques were identified and 50 plaques were further plaque purified two more times under the same immunoscreening condition as described above.

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D. PCR screening of purified phage plugs

The phage plugs identified in the foregoing immunoscreening study were then further analyzed by PCR amplification using the primers described above in section 8B. DNA from the 50 plaques was amplified using a mixture of the 4 primers identified by SEQ ID NO: 25, SEQ ID NO:26, SEQ ID NO:27 and SEQ ID NO:28. PCR amplification was conducted using standard techniques. One resulting PCR amplification product comprised a fragment of about 700 nucleotides. The PCR product was cloned into the InVitrogen, Corp., TA™ cloning vector (procedures provided by InVitrogen,

Corp.) and subjected to DNA sequence analysis using standard techniques. The phagemid from the purified phage that were determined to contain sequences encoded in the 700-bp PCR product were rescued and subjected to DNA sequence analysis using standard techniques.

5 A clone was isolated that included about a 1752-nucleotide insert, referred to herein as nDerf98₁₇₅₂. Nucleic acid sequence was obtained using standard techniques from nDerf98₁₇₅₂, to yield a *Dermatophagoides farinae* nucleic acid molecule named nDerf98₁₇₅₂ composed of a coding strand having nucleic acid sequence SEQ ID NO:14 and a complementary strand having a nucleic acid sequence SEQ ID NO:16. Translation of SEQ ID NO:14 suggests that nucleic acid molecule nDerf98₁₇₅₂ encodes a full-length flea protein of about 555 amino acids, referred to herein as PDerf98₅₅₅, having amino acid sequence SEQ ID NO:15, assuming an open reading frame in which the first codon spans from nucleotide 1 through nucleotide 3 of SEQ ID NO:14 and a stop codon spanning from nucleotide 1666 through nucleotide 1668 of SEQ ID NO:14. The amino acid sequence of PDerf98₅₅₅ is encoded by the nucleic acid molecule nDerf98₁₆₆₅, having a coding strand with the nucleic acid sequence SEQ ID NO:17 and a complementary strand with the nucleic acid sequence SEQ ID NO:19. PDerf98₅₅₅, also represented by SEQ ID NO:18, has an estimated molecular weight of about 63.2 kD and an estimated pI of about 5.33. Analysis of SEQ ID NO:15 suggests the presence of a signal peptide spanning from
10 about amino acid 1 through about amino acid 19. The proposed mature protein, denoted herein as PDerf₅₃₆, contains about 536 amino acids, the sequence of which is represented herein as SEQ ID NO:21, and is encoded by a nucleic acid molecule referred to herein as
15 nDerf98₁₆₀₈, represented by SEQ ID NO:20, the coding strand, and SEQ ID NO:22, the
20 about amino acid 1 through about amino acid 19. The proposed mature protein, denoted herein as PDerf₅₃₆, contains about 536 amino acids, the sequence of which is represented herein as SEQ ID NO:21, and is encoded by a nucleic acid molecule referred to herein as
nDerf98₁₆₀₈, represented by SEQ ID NO:20, the coding strand, and SEQ ID NO:22, the

complementary strand. The amino acid sequence of flea PDerf98₅₃₆ (i.e. SEQ ID NO:21) predicts that PDerf98₅₃₆ has an estimated molecular weight of 61.2 kD, and an estimated pI of about 5.26.

Comparison of amino acid sequence SEQ ID NO:15 with amino acid sequences reported in GenBank indicates that SEQ ID NO:15 showed the most homology, i.e., about 42% identity, with a chitinase protein from *Anopheles gambiae* (GenBank accession number 2654602). Comparison of nucleic acid sequence SEQ ID NO:17 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:17 showed the most homology, i.e., about 58% identity between SEQ ID NO:17 and *Chelonus sp.* venom chitinase mRNA (GenBank accession number U10422).

Example 9

This example describes the purification of a 60-kD protein that binds to IgE from dogs known to be allergic to mite allergens and partial amino acid sequences derived from this 60-kD protein.

A. Purification of a 60 kD protein

D. farinae extract was prepared and fractionated on a Sephadryl S-100 column according to the methods described above in Example 1. Fractions were collected from the Sephadryl S-100 column after the excluded peak (fractions 29 through 35) and were pooled. The pooled fractions were then diluted 1:1 with 10 mM Tris-HCl, pH 8, and applied to a Q-sepharose column and fractions obtained using the methods described above in Example 1. The fraction that eluted in 0.4 M Tris-HCl was concentrated and further purified through a TMS 250 reverse phase HPLC column using the methods described above in Example 1. The proteins in the fractions were resolved by 14% Tris-

glycine SDS-PAGE using similar methods described for resolution of proteins on the 12% gel in Example 1. The stained gel is shown in Fig. 2. A protein was identified having a molecular weight of about 60 kD (Fig. 2, lane 4) of about 90% purity that eluted at about 50% B (.05%TA in 90% acetonitrile). The molecular weight of the denoted 60-kd protein was estimated to be 56.11 kd using the BioRad Multi-Analyst/PC Version 1.1 program and Mark-12 protein molecular weight markers. The about 60-kd protein is referred to herein as mapD protein.

5 B. Partial N-terminal and internal sequence obtained from the 60-kd protein

The eluted protein from Part A, above, was blotted onto PVDF, which was stained with Coomassie R-250 and destained using standard procedures. The protein corresponding to the about 60-kd band was excised and subjected to N-terminal amino acid sequencing using techniques known to those skilled in the art. A partial N-terminal amino acid sequence of about 25 amino acids was deduced for the protein and the amino acid sequence, represented herein as SEQ ID NO:23, was determined to be: Xaa Leu Glu Pro Lys Thr Val Cys Tyr Tyr Glu Ser Trp Val His His Arg Gln Gly Glu Gly Lys Met Asp 10 Pro (wherein Xaa refers to any amino acid).

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The protein corresponding to the 60 kd region was also submitted to proteolytic cleavage in order to obtain internal amino acid sequence data. Digestion of the 60-kd protein and reverse-phase chromatography were carried out as described in Example 1. 20 Four proteolytic fragments were isolated and sequenced, and are referred to herein as map(13), map(14), map(15), and map(16).

The N-terminal partial amino acid sequence of map(13) was determined to be Gln Tyr Gly Val Thr Gln Ala Val Val Thr Gln ProAla, also denoted SEQ ID NO:29. The N-

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terminal partial amino acid sequence of map(14) was determined to be Asp Glu Leu Leu Met Lys Ser Gly Pro Gly Pro, also denoted SEQ ID NO:30. The N-terminal partial amino acid sequence of map(15) was determined to be Asp Met Glu His Phe Thr Gln His Lys Gly Asn Ala Lys Ala Met Ile Ala Val Gly Gly Ser Thr Met Ser, also denoted SEQ ID NO:31. The N-terminal partial amino acid sequence of map(16) was determined to be Asp Ala Asn Glu Glu Ala Arg Ser Gln Leu Pro Glu Thr Ala Met Val Leu Ile Lys Ser Gln, denoted SEQ ID NO:32.

Example 10.

This example describes the isolation and sequencing of nucleic acid molecules encoding a portion of the *D. farinae* 60 kD (mapD) allergen.

A *D. farinae* library was prepared as described previously in Example 8. A degenerate synthetic oligonucleotide primer was designed from the N-terminal amino acid sequence deduced for *D. farinae* 60 kD-protein (SEQ ID NO:23): Primer 1, a sense primer corresponding to amino acid residues from about 3 through about 11 of SEQ ID NO:23 has the sequence 5' GAACCAAAA CHGTNTGYTA YTAYG 3', also known as SEQ ID NO:46, where H represents A or C or T, N represents A or C or G or T, and Y represents C or T. PCR amplification of fragments from the *D. farinae* library was conducted using standard techniques. A PCR amplification product was generated using a combination of SEQ ID NO:46 (primer 1) and the M13 forward universal primer 5'GTAAAACGACG GCCAGT 3', denoted SEQ ID NO:47.

A second, nested PCR reaction was carried out on the products of the first PCR reaction. A synthetic oligonucleotide was synthesized that corresponded to a region spanning from about amino acid residue 1 through amino acid residue 10 of the 60-kD

protein internal amino acid sequence, SEQ ID NO:31. This primer, primer 2, has the nucleic acid sequence 5' GATATGGAAC ATTYACHCA ACAYAARGG 3', denoted SEQ ID NO:48, where R represents A or G. A PCR amplification product was generated using the combination of primer 2, SEQ ID NO:48, and the T7 standard primer, 5'

5 GTAATACGAC TCACTATAAG GC 3', denoted SEQ ID NO:49. The resultant PCR product was subjected to DNA sequence analysis using standard techniques.

The PCR product was sequenced and found to contain 510 nucleotides, and is known as nDerf60₅₁₀. The nucleotide sequence of the coding strand of nDerf60₅₁₀ is represented herein as SEQ ID NO:43, and its complement is denoted SEQ ID NO:45.

10 Translation of SEQ ID NO:43 suggests that nDerf60₅₁₀ encodes a partial *D. farinae* 60-kD protein of about 170 amino acids, referred to herein as PDerf60₁₇₀, with an amino acid sequence denoted SEQ ID NO:44, assuming an open reading frame in which the first codon spans from about nucleotide 1 through nucleotide 3 of SEQ ID NO:43, and the last codon spanning from about nucleotide 508 through about nucleotide 510 of SEQ ID

15 NO:43. PDerf60₁₇₀ has an estimated molecular weight of 19.2 kD and an estimated pI of about 6.51.

Nucleic acid molecule nDerf60₅₁₀ was used as a probe to isolate a nucleic acid molecule that encodes a protein corresponding to a full-length, or larger partial *D. farinae* 60-kD protein. Using procedures described previously in Example 8, the whole *D.*

20 farinae library was screened with the nucleic acid SEQ ID NO:43 radiolabeled with ³²P using standard techniques. Hybridization was done in 6X SSC, 5X Denhardt's solution, 0.5% SDS, 100 mg/ml ssDNA, at 55°C, for about 36 hours. The filters were washed 3

times, for 30 minutes per wash, at 55°C in 2X SSC, 0.2% SDS, followed by a final wash of about 30 minutes in 0.2X SSC, 0.2% SDS.

PCR amplification was carried out on the primary phage plugs. Primer 1, denoted as SEQ ID NO:46, and T7 standard primer, denoted as SEQ ID NO:49, were used as the primers, and a PCR product was generated. Preliminary sequence analysis of this 1.6 kilobase PCR product showed that it represents a nucleic acid sequence that contains the complete sequence encoding the PDerf60 full-length protein.

Comparison of PDerf60₁₇₀, the amino acid sequence of SEQ ID NO:44, with amino acid sequences reported in GenBank indicates that PDerf60₁₇₀ showed the most homology, i.e. about 39% identity, with a chitinase protein precursor from *Aphanodidium album*. (GenBank accession number P32470). Nucleic acid sequence SEQ ID NO:43 showed no significant homology to any of the sequences submitted to GenBank.

Example 11

This example describes the isolation of nucleic acid molecules encoding *Dermatophagoides pteronyssinus* 98 kD allergen protein.

Nucleic acid molecules with high homology to the *D. farinae* 98 kD allergen (map B) were isolated from a *D. pteronyssinus* cDNA library by hybridization with a 32-P labeled cDNA encoding the *D. farinae* HMW-map composition.

A *D. pteronyssinus* cDNA library was prepared as follows. Total RNA was extracted from approximately 2 grams of *D. pteronyssinus* mites, using an acid-guanidium-phenol-chloroform method, described by Chomzynski et al., 1987, *Anal. Biochem* 162: pp 156-159. Poly A+ selected RNA was separated from the total RNA preparation by oligo-dT cellulose chromatography using the mRNA Purification Kit (available from

Pharmacia, Newark, NJ), according to the method recommended by the manufacturer. A whole *D. pteronyssius* cDNA library was constructed in lambda-Uni-ZAP™ XR vector (available from Stratagene, La Jolla, CA), using Stratagene's ZAP-cDNA Synthesis Kit protocol. Approximately 5 milligram (mg) of Poly A+ RNA was used to produce the *D. pteronyssius* cDNA library.

Using a modification of the protocol described in the cDNA Synthesis Kit (available from Stratagene), the whole *D. pteronyssius* cDNA library was screened, using duplicate plaque lifts, with a 32P-labeled cDNA encoding the *D. farinae* 97 kD Map B allergen, i.e. SEQ ID NO:17. Hybridization was done in 6X SSC (for recipe see Sambrook, et al., *ibid.*), 5X Denhardt's solution (for recipe see Sambrook, et al., *ibid.*), 0.5% sodium dodecyl sulfate (SDS) (available from Sigma), and 100 mg/ml of single stranded DNA (available from Sigma), at 55°C, for about 36 hours. The filters were washed 3 times, for about 30 minutes per wash, at 55°C, in 2X SSC, 0.2% SDS, followed by a final wash of about 30 minutes, at 55°C, in 0.2X SSC, 0.2% SDS. A plaque purified clone of the *D. pteronyssius* nucleic acid molecule encoding the *D. pteronyssius* 97 kD allergen (map B) was converted into a double stranded recombinant molecule using the ExAssist™ helper phage and SOLR™ E. coli according to the *in vivo* excision protocol described in the ZAP-cDNA Synthesis Kit (all available from Stratagene). The plasmid containing the *D. pteronyssius* clone was subjected to DNA sequence analysis using standard techniques. DNA sequence analysis, including the determination of molecular weight and isoelectric point (pI) was performed using the GCG™ program.

A clone was isolated that included an about 1621-nucleotide insert, which includes the full-length coding region, referred to herein as nDerp98₁₆₂₁, with a coding

strand represented as SEQ ID NO:34 and a complementary strand represented as SEQ ID NO:36. The apparent start and stop codons span from nucleotide 14 through nucleotide 16, and from nucleotide 1541 through nucleotide 1543, respectively, of SEQ ID NO:34. A putative polyadenylation signal (5'AATAAA 3') is located in a region spanning from nucleotide 1584 to 1589 of SEQ ID NO:34.

Translation of SEQ ID NO:34 yields a protein of about 509 amino acids, denoted PDerp98₅₀₉, the amino acid sequence of which is presented as SEQ ID NO:35. The nucleic acid molecule consisting of the coding region encoding PDerp98₅₀₉ is referred to herein as nDerp98₁₅₂₇, the nucleic acid sequence of which is represented as SEQ ID NO:37 (the coding strand), and SEQ ID NO:39 (the complementary strand). The amino acid sequence of PDerp98₅₀₉, also represented herein as SEQ ID NO:38, has an estimated molecular weight of about 58.9 kD and an estimated pI of about 5.61. Analysis of PDerp98₅₀₉ suggests the presence of a signal peptide spanning from about amino acid 1 through about amino acid 19. The proposed mature protein, denoted herein as PDerp98₄₉₀, contains about 490 amino acids, and is represented herein as SEQ ID NO:41. The amino acid sequence of PDerp98₄₉₀ predicts the protein to have an estimated molecular weight of about 56.8 kD, and an estimated pI of about 5.49, as well as two asparagine-linked glycosylation sites extending from about amino acid 115 to about amino acid 117, and extending from about amino acid 240 to amino acid 242, respectively. The nucleic acid molecule encoding PDerp98₄₉₀ is known as nDerp98₁₄₇₀, with a coding strand represented by SEQ ID NO:40 and a complementary strand represented by SEQ ID NO:42.

A BLAST search was performed as described previously. PDerp98₅₀₉, SEQ ID NO:35, showed the highest homology at the amino acid level with the *Manduca sexta* chitinase (SwissProt accession number p36362), with about a 34% identity. nDerp98₁₆₂₁, SEQ ID NO:34, showed the highest homology at the nucleic acid level to *Chelonus sp.* 5 chitinase (accession number U10422), with about a 49% identity. Comparison of cDNA regions corresponding to the coding regions for the *D. farinae* 98 kD allergen protein and the cDNA regions corresponding to the coding regions for the *D. pteronyssius* 98 kD allergen protein shows an identity of about 84%.

Example 14.

10 This example demonstrates the binding of the *D. farinae* HMW-map composition to human IgE in human sera isolated from humans known to be allergic to mite allergens.

15 A technique called RAST, or radio-allergo-absorbent test, was used because the amount of human IgE present in human sera is quite low. RAST was essentially performed as described in Aalberse, RC et al., (1981) *J. Allergy Clin Immun.* 68: pp 356-364. To calculate the unit IU/ml, a standard curve was derived by performing RAST with several dilutions of a well-characterized chimeric human/mouse IgE monoclonal antibody against Derp2, (human IgE/monoclonal anti-Derp2, following the procedure of Schuurman, et al. (1997) *J Allergy Clin Immunol.* 99: pp 545-550).

Briefly, 50 µg of the HMW-map composition, purified as described in Example 1, 20 was coupled to 50 mg of CNBr-activated Sepharose 4B (available from Pharmacia, Piscataway, NJ), according to the manufacturer's protocols. Human sera were selected (17 different samples, total) on the basis of a positive RAST for whole mite *D. farinae*

extracts, a positive RAST number is greater than 1 IU/ml). Two negative (less than 0.3 IU) control sera were also included.

To test each individual serum sample, 0.5 mg of the *D. farinae* HMW-map composition-coupled Sepharose was incubated with 50 μ l serum in a total volume of 300 5 μ l of PBS-T (Phosphate buffered saline with added 0.1% volume/volume Tween-20, available from Sigma). Incubation was overnight at 27°C, with shaking. After incubation, the coupled Sepharose was washed five times with PBS-T. Radiolabelled (¹²⁵Iodine) sheep anti-human IgE, made by standard radioiodination protocols, (diluted in PBS-T with 4.5% bovine serum and 0.5% sheep serum, v/v) in a total volume of 750 μ l, 10 was added and incubated overnight at 27°C. After incubation, the coupled Sepharose was washed four times with PBS-T and counted in a gamma-counter to determine the amount of radiolabeled sheep anti-human IgE bound to the HMW-map composition-coupled Sepharose. The results are shown in Table 4.

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Table 4. Binding of human IgE to HMW-map composition from *D. farinae*

Serum number	RAST, <i>D. farinae</i> whole extract, IU	RAST, HMW-map comps'n., IU
1445	> 100	48
1456	>100	42
5 1458	21.1	0.5
1460	14.1	2.5
1463	37.6	0.1
1464	37.2	2.0
1465	14.5	0.7
10 1466	89.9	7.7
1468	>100	19.9
1471	31.9	0.8
1491	23.8	1.0
1496	25.3	3.6
15 1505	5.1	0.2
1523	1.0	<0.1
1529	1.2	0.7
1530 (control)	0.2	<0.1
20 1531 (control)	0.1	<0.1

Almost 75% of patients (11 of 15) who showed sensitivity to *D. farinae* whole mite extracts were sensitive to the HMW-map composition antigen, implying that the HMW-map composition antigen is a major antigen for *D. farinae* sensitive humans. Sensitivity to the HMW-map composition was defined as a RAST of greater than or equal to 0.5 IU.

25. Example 15.

This example demonstrates that the *D. farinae* HMW-map composition described in Example 1 includes a glycoprotein.

About (5.4 μg) of a *D. farinae* HMW-map composition prepared in accordance with Example 1 was applied to SDS PAGE and electrophoresis was done according to standard techniques. The protein was blotted to a nitrocellulose membrane according to standard techniques, and glycoprotein was detected using the DIG™ Glycine Detection Kit (available from Boehringer Mannheim, Indianapolis, IN), using the manufacturer's protocol. The region corresponding to the HMW-map region showed a positive reaction with the kit, indicating that the HMW-map composition includes a glycoprotein.

Example 16.

This example shows that the *D. farinae* HMW-map composition retains its character as an allergen even when the amino acid residues are removed, both by chemical and enzymatic means. The results suggest that the main epitope(s) could be a carbohydrate epitope including a polysaccharide attached to an N-linked or O-linked glycosylation site on the HMW-map composition.

A. Protein elimination by chemical means (β -elimination of proteins)

Twelve μg (microgram) of HMW-map composition (purified as described in Example 1) was dissolved in 100 μl (microliter) of distilled deionized water. To this mixture was added 5 μl 10 M (molar) NaOH and 3.8 mg (milligram) NaBH₄ (available from Sigma) to give a final concentration of 0.5 M NaOH and 1 M NaBH₄. This reaction mixture was heated at 50°C for 30 minutes, then cooled, and 100 μl acetone was added.

To this mixture, sufficient amount, i.e. approximately 150 μl , of Dowex 50 (H+) (available from Pharmacia) was added to make the solution slightly acidic. The Dowex 50 adsorbed and removed the protein, leaving any sugar moieties in the supernatant. The mixture was centrifuged in a microcentrifuge and washed three times with 100 μl of

5

water. The combined supernatants from the centrifugations were evaporated to dryness, then washed five times from a methanol:HCl solution (1000:1 v/v), evaporating to dryness after each wash, to remove salts. The mixture was dissolved in 100 μ l of water, and a portion (20 μ l) was analyzed by SDS-PAGE using standard techniques, and both Coomassie blue and Silver staining were used to determine the amount of protein in the chemically treated samples. No protein was detected by either Coomassie or Silver staining, indicating removal of protein. Any sugar moieties on the protein would be unaffected by these conditions.

10

The remainder of the residue from each sample was subjected to ELISA analysis as described in Example 4. Briefly, 100 ng of either the β -eliminated sample or of non- β -eliminated sample of the HMW-map composition was coated onto the Immulon plates, and ELISAs were carried out as described in Example 4 with a *D. farinae* sensitive dog sera pool, a *D. farinae* sensitive cat sera pool, and various individual dog sera that are either *D. farinae* sensitive or not sensitive (as measured by ELISA). The results are shown in Table 5.

15

Table 5. Reactivity of dog and cat sera to HMW-map composition and to β -eliminated HMW-map composition (which is carbohydrate only)

Sera used	β -eliminated HMW-map, OD (carbohydrate antigen)	untreated HMW-map comps'n., OD X 10 ³
<i>D.farinae</i> dog pool	1233	1931
<i>D.farinae</i> cat pool	2837	3115
dog 1621A	15	0
dog 1621C	24	21
dog 1621S	59	420
dog 1626C	23	214
dog SPF-2	16	0

Results from Table 5 indicate that the β -eliminated HMW-map composition sample still retains the ability to bind IgE from dog and cat sera that is sensitive to *D. farinae* HMW-map composition, indicating that the glycans attached to the protein constitute a major epitope of the HMW-map composition allergen protein.

5 B. Protein Elimination by enzymatic means.

14 μ g of HMW-map composition (purified as described in Example 1) was digested with 1 μ g Endoproteinase K, available from Sigma, to remove the protein moiety of the molecule. The digestion reaction took place at 56°C for 24 hours, after which the endoproteinase in the reaction was heat-denatured in boiling water for 10 minutes.

10 A portion of this reaction was analyzed by SDS-PAGE using standard techniques, and both Coomassie blue and Silver staining were used to detect the presence of protein in the enzymatically digested samples. No HMW-map composition was detected by either Coomassie or Silver staining, indicating elimination of the HMW-map composition. Any glycan that was attached via a glycosylation site on the protein would be unaffected by these conditions.

15 The remainder of the enzymatically digested reaction was tested by ELISA in the manner described in Example 4. Briefly, 100 ng of either the proteinase-K-digested sample or of a non-digested sample of the HMW-map composition was coated onto Immulon plates, and ELISAs were carried out as described in Example 4 with various individual dog sera that were either *D. farinae* sensitive or not sensitive (as measured by ELISA). The results are shown in Table 6.

Table 6. Reactivity of dog sera to HMW-map composition and to Endoproteinase-K digested HMW-map composition.

dog #	<i>D. fariniae</i> sensitive?	OD, wells coated with HMW-map comp's'n.	OD, wells coated with Proteinase K digested HMW-map
5	yes	120	122
	yes	1637	1561
	yes	858	383
	yes	914	509
	yes	277	227
10	yes	2891	2636
	no	10	11
	yes	4056	3880
	yes	1920	1626
	yes	472	432
15	yes	328	213
	yes	2913	2530
	yes	1232	984
	yes	3153	2355
	no	6	46
20	yes	860	339
	yes	2429	750
	yes	1194	351
	yes	2655	1443
	yes	3285	1207
25	yes	2636	1240
	yes	1097	848
	yes	1621	1408
	yes	2113	1592
	yes	1169	408
30	yes	4200	4200
	yes	4200	4200
	yes	3222	2932
	yes	2468	2118
	yes	3339	2454
35	no	0	4

¹ by ELISA in a separate experiment

Results from Table 6 indicate that the proteinase-K digested HMW-map composition sample still retains the ability to bind IgE from dog and cat sera that is sensitive to *D. farinae* HMW-map composition, suggesting that the glycans attached to the protein constitute a major epitope on the HMW-map composition.

5 Example 17

This example describes attempts to remove N-linked glycans from the HMW-map composition.

HMW-map composition (2 μ g), purified as in Example 1, was digested with N-glycosidase F (available from Boehringer-Mannheim), according to the manufacturer's directions. The digestion was analyzed by SDS-PAGE and stained according to standard protocols. 2 μ g Fetuin (available from Sigma) was used as a positive N-linked glycosylated protein control. Analysis of the SDS-PAGE showed that there were no apparent differences in the molecular weights of the intact and digested map B protein. The positive control, fetuin, did show a reduction of molecular weight after digestion with N-glycosidase F. This result indicates that there are no N-linked glycans on the HMW-map composition, or alternatively that there are only small sized N-glycans on the HMW-map composition.

15 Example 18

This example describes the isolation and sequencing of a nucleic acid molecule encoding the full length *Dermatophagoides farinae* 60 kD allergen.

This nucleic acid molecule was isolated from a *Dermatophagoides farinae* cDNA library by its ability to hybridize with a 32 P-labeled cDNA encoding a portion of the *Dermatophagoides farinae* 60 kD allergen described in Example 10.

A *Dermatophagoides farinae* cDNA library was prepared as follows. Total RNA was extracted from approximately 2 grams of *D. farinae* mites, using an acid-guanidinium-phenol-chloroform method similar to that described by Chomzynski et al., 1987, *Anal. Biochem.* 162,156-159. Poly A⁺ selected RNA was separated from the total
5 RNA preparation by oligo-dT cellulose chromatography using the mRNA Purification Kit (available from Pharmacia Biotech, Newark, NJ), according to the method recommended by the manufacturer. A whole mite cDNA library was constructed in lambda-Uni-ZAPTM XR vector (available from Stratagene), using Stratagene's ZAP-cDNA Synthesis Kit protocol. Approximately 5 µg of Poly A⁺ RNA was used to produce
10 the *D. farinae* cDNA library.

Using a modification of the protocol described in the cDNA Synthesis Kit, the whole mite cDNA library was screened, using duplicate plaque lifts, with ³²P-labeled cDNA nDerf60₅₁₀. Hybridization was done at 6XSSC, 5X Denhardt's solutions, 0.5 % SDS, 100 mg/ml of ssDNA and, at 52°C, for 18 hr. The filters were washed 2 times, for
15 30 minutes per wash, at 55°C in 2XSSC, 0.2% SDS, followed by a final wash of 30 minutes in the same buffer except using about 0.2XSSC. A plaque purified clone of the nucleic acid molecules encoding the *D. farinae* 60 kD allergen was converted into a double stranded recombinant molecule, herein denoted as nDerf60₁₄₅₅, using the ExAssistTM helper phage and SOLRTM *E. coli* according to the *in vivo* excision protocol
20 described in the ZAP-cDNA Synthesis Kit (available from Stratagene). Double-stranded plasmid DNA was prepared using an alkaline lysis protocol, such as that described in Sambrook et al., *ibid.*

Example 19

This example describes the sequencing of a *D. farinae* nucleic acid molecule of the present invention.

The plasmid containing nDerf60₁₄₅₅ was sequenced by the Sanger dideoxy chain 5 termination method, using the PRISM™ Ready Dye Terminator Cycle Sequencing Kit with Ampli Taq DNA Polymerase, FS (available from the Perkin-Elmer Corporation, Norwalk, CT). PCR extensions were done in the GeneAmp™ PCR System 9600 (available from Perkin-Elmer). Excess dye terminators were removed from extension products using the Centriflex™ Gel Filtration Cartridge (available from Advanced 10 Genetics Technologies Corporation, Gaithersburg, MD) following the manufacturer's standard protocol. Samples were resuspended according to ABI protocols and were run on a Perkin-Elmer ABI PRISM™ 377 Automated DNA Sequencer. DNA sequence analysis, including the compilation of sequences and the determination of open reading frames, was performed using the GCG™ program (available from Genetics Computer 15 Group, Madison, WI). Protein sequence analysis, including the determination of molecular weight and isoelectric point (pI) was performed using the GCG™ program.

An about 1455 nucleotide consensus sequence of the entire nDerf60₁₄₅₅ nucleic acid molecule was determined; the sequences of the two complementary strands are presented as SEQ ID NO:50 (the coding strand) and SEQ ID NO: 52 (the complementary 20 strand). The nDerf60₁₄₅₅ sequence contains a full length coding region. The apparent start and stop codons span nucleotides from 14 through 16 and from 1400 through 1402, respectively, of SEQ ID NO: 50. A putative polyadenylation signal (5' AATAAA 3') is located in a region spanning from about nucleotide 1408-1413 of SEQ ID NO: 50.

Translation of SEQ ID NO: 50 yields a protein of 462 amino acids, denoted PDerf60₄₆₂, the amino acid sequence of which is presented in SEQ ID NO: 51. The nucleic acid molecule consisting of the coding region encoding PDerf60₄₆₂ is referred to herein as nDerf60₁₃₈₆, the nucleic acid sequence of which is represented in SEQ ID NO: 53 (the coding strand) and SEQ ID NO: 54 (the complementary strand). The amino acid sequence of PDerf60₄₆₂ (i.e., SEQ ID NO: 51) predicts that PDerf60₄₆₂ has an estimated molecular weight of about 52.1 kD and an estimated pI of about 5.73. Analysis of SEQ ID NO: 51 suggests the presence of a signal peptide encoded by a stretch of amino acids spanning from amino acid 1 through amino acid 25. The proposed mature protein, 10 denoted herein as PDerf60₄₃₇, contains about 437 amino acids which is represented herein as SEQ ID NO: 56. The amino acid sequence of PDerf60₄₃₇ (i.e., SEQ ID NO: 56) predicts that PDerf60₄₆₂ has an estimated molecular weight of about 50.0 kD, an estimated pI of about 5.61. and one predicted asparagine-linked glycosylation site extending from amino acids 313 through 315. The nucleic acid molecule encoding the 15 mature protein is denoted SEQ ID NO: 55 and its reverse complement is denoted SE ID NO: 57.

A BLASTp search was performed according to Altschul, et al, (1990), *J. Mol. Biol.* 215:403-410; and Altschul, et al, (1997), *Nucleic Acids Res.* 25:3389-3402. The protein search was performed using SEQ ID NO:51, which showed significant homology 20 to chitinase molecules. The highest scoring match of the homology search at the amino acid level was PIR accession number A53918: *Chelonus sp.* chitinase precursor, which was about 32% identical with SEQ ID NO:51. At the nucleotide level, the search was performed using SEQ ID NO:53, which did not show significant similarity to any

sequences in the database. Sequence analysis was performed using the GCG GAP program as described above.

Example 20

This example further describes the characterization of the *D. farinae* HMW-map
5 composition (also referred to as Der f 15).

Nucleic acid molecule nDerf98₁₇₅₂ of Example 8 was inserted into appropriate expression vectors and expressed in *E. coli* and *P. pastoris*. When the resulting protein, PDerf98₅₅₅ was expressed in *E. coli* or *P. pastoris*, sensitized dog sera, produced as described in Example 4, failed to recognize the recombinant protein. This is in contrast
10 to the positive results obtained when the native *D. farinae* HMW-map composition of Example 1 (also referred to as native Der f 15) was used; see Example 4.

The non-reactivity of the protein expressed in *E. coli* is consistent with the results shown in Example 16, in which it was shown that the native HMW allergens retain their character as allergens, even after the amino acids are removed.

15 All of these results together suggest that the main epitope(s) are carbohydrate regions of the molecule or some other secondary modification.

The antigenicity of the native Der f 15 protein is not lost after periodate treatment; generally carbohydrate epitopes are destroyed by periodate except for those further substituted with additional groups or those having an unusual sugar with no geminal
20 hydroxyl groups.

The native Der f 15 antigen was analyzed for carbohydrate content. A substantial amount of carbohydrate was found, about 30% by weight. Specifically, mannose constituted approximately 2.8% by weight of the antigen; galactose approximately

23.2%; glucose approximately 4.3% (the presence of glucosyl residue must be considered tentative as glucose often contaminates glycoprotein samples); and HexNAc at detectable levels; further investigation revealed that the HexNAc were GlcNAc and GalNAc.

The native Der f 15 protein was treated with base in the presence of NaBH₄ and
5 analyzed by a P-4 sizing chromatography. O-linked oligosaccharides present in Der f 15 were found to void the column. This result is consistent with either very large O-linked oligosaccharides or the presence of acidic groups on the oligosaccharides such as sulfate. Attempts to determine the presence or absence of sulfate more directly gave ambiguous results.
10

Der f 15 was treated at pH 4, pH 5, and pH 7 overnight at 37° C. The resulting samples were then probed with antibody to the protein or dog serum known to be reactive with Der f 15. In the samples treated at pH 5 and pH 7, all of the dog antiserum epitope was destroyed, but in the samples treated at pH 4, some activity remained. The anti-Der f 15 antibody shows that the molecular weight of Der f 15 was decreased at all
15 pH's with some original material left at pH 4, as though deglycosylation was occurring. It is not known whether this change was self catalyzed by the Der f 15 protein or occurred chemically; while not being bound by theory, it is believed that self catalysis was involved since the loss of the epitope occurred under such mild conditions.

Example 21

20 This example describes the binding of several house dust mite (HDM) allergens to feline IgE in cat serum.

The allergen profile of the IgE response of cats to house dust mites appears to be different from that of dogs. An examination of the results of IgE testing on cat sera

submitted to Heska's Veterinary Diagnostic Laboratories (VDL) in January 2000 shows that 40% of all allergen-specific IgE positive cats had anti-HDM IgE. All the cats were positive to both *D. farinae* and *D. pteronyssinus*. Eighty-eight sera known to be positive for *D. farinae* were assayed by ELISA on highly purified preparations of Der f 1, Der f 2,

- 5 Der f 15, and the 60 kD allergen. In this assay, 32% of the cats were positive for Der f 1, 42% were positive for Der f 2, 68% were positive for Der f 15, and 86% were positive for the 60 kD allergen.

While various embodiments of the present invention have been described in detail, it is apparent that modifications and adaptations of those embodiments will occur 10 to those skilled in the art. It is to be expressly understood, however, that such modifications and adaptations are within the scope of the present invention, as set forth in the following claims.

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